Iron and Steel Engineer

Established 1907 as Proceedings of A. I. & S. E. E.

JOHN F. KELLY, EDITOR

CONTENTS

Volume X. MAY, 1933. Number V.

BOILER WATER CONDITIONING WITH ALUMINA AND MAGNESIA—by W. F. Peters, Jr., Water Engineer, Pelham, N. Y. 117

PRESIDENT'S MESSAGE TO A. I. & S. E. E. DISTRICT SECTION OFFICERS AND COMMITTEEMEN 122

THE APPLICATION OF THE SYNCHRONOUS TIE TO MODERN CONTROL PROBLEMS—by R. H. Wright, Steel Mill Engineer, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa. 123

DISCUSSION—THE APPLICATION OF THE SYNCHRONOUS TIE TO MODERN CONTROL PROBLEMS—Discussion presented by J. W. Bates, R. H. Wright, O. G. Rutemiller, N. C. Goin, C. O. Franklin, R. H. Ellis, D. W. Dean, W. Anderson, P. W. Miller, F. E. Fairman, A. C. Dyer, F. P. May, G. W. First, L. E. Markle and K. N. Reardon 126

INDUSTRIAL LIGHTING PROGRESS—by P. R. Holmes, Illuminating Engineer, General Electric Company, Philadelphia, Pa. 130

SLOW BLOWING-BLAST FURNACES—by W. A. Haven, Cleveland, Ohio 133

DISCUSSION—NON-METALLIC BEARINGS—Discussion presented by N. C. Bye, L. F. Coffin, W. H. Burr, F. W. Vogt and C. M. Thompson 134

THE EXTERNAL HEAT LOSS OF A BLAST-FURNACE—by D. F. Marshall, B. Sc. Tech., Sheffield, England 136

A. C. CUMMINS MADE GENERAL SUPERINTENDENT, CARNEGIE STEEL CO., DUQUESNE, PA. 138

ASSOCIATION NOTES 138

ITEMS OF INTEREST 139

A. I. & S. E. E. INSPECTION TRIP PROGRAM AND SCHEDULE II

EDITORIALS III

INDEX TO ADVERTISERS IV

Published Monthly by

Association of Iron and Steel Electrical Engineers

BOARD OF DIRECTORS—1932-1933

President, J. D. Donovan, Electrical & Mechanical Superintendent, Republic Steel Corp., Massillon, Ohio.

1st Vice Pres., W. E. Miller, Electrical & Mechanical Supt., Bethlehem Steel Company, Johnstown, Pa.

2nd Vice Pres., W. H. Burr, Electrical & Mechanical Supt., Lukens Steel Company, Coatesville, Pa.

Secretary, J. A. Clauss, Chief Engineer, Great Lakes Steel Corp., Ecorse, Mich.

Past Pres., J. J. Booth, Electrical Supt., National Tube Company, Gary, Ind.

Past Pres., F. O. Schnure, Electrical Supt., Bethlehem Steel Company, Sparrows Point, Md.

Director at Large, G. R. Carroll, Electrical Supt., Jones & Laughlin Steel Corp., Aliquippa, Pa.

Honorary Director, James Farrington, Electrical Supt., Wheeling Steel Corp., Steubenville, Ohio.

Honorary Director, E. Friedlander, Pittsburgh, Pa.

Director, H. D. Esterly, Electrical Supt., Alan Wood Steel Company, Conshohocken, Pa.

Director, E. C. Marshall, Electrical Supt., Youngstown Sheet & Tube Company, East Chicago, Ind.

Director, R. F. Sanner, Assistant Electrical Engineer, Carnegie Steel Company, Duquesne, Pa.

Director, W. H. Gilbert, Assistant to Mechanical Engineer, Tennessee Coal, Iron & R. R. Co., Birmingham, Ala.

Director, J. L. Miller, Steam Engineer, Carnegie Steel Company, Youngstown, Ohio.

Director, A. D. Adams, Assistant Supt., Spang Chalfant & Company, Inc., Ambridge, Pa.

Director, P. F. Haberstick, Safety Engineer, Wheeling Steel Corp., Wheeling, W. Va.

Director, A. L. Foell, Chief Engineer, Arthur G. McKee Company, Cleveland, Ohio.

Managing Director, John F. Kelly, Empire Building, Pittsburgh, Pa.

Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879.
Subscription Price $5.00 per Year. Single Copy $1.00.

INSPECTION TRIP

E. W. BLISS COMPANY, SALEM, OHIO

SATURDAY, 10:30 A. M. MAY 20, 1933

NEW FOUR HIGH MILL

Features:

LINK HOUSING
Inverted Screw Down Type

LAMINATED FORGED STEEL HOUSINGS
(A - New - Use - For Steel)

MOST POWERFUL SCREW DOWN EVER BUILT

(Pressure 15,000,000 lbs.)

Backing Rolls 56 in. dia.; 84 in. long.
Working Rolls 20 in. dia.; 84 in. long.
Special Roller Bearings Used.

Mill Developed for Tin Plate and Sheet Industry.

INSPECTION TRIP SCHEDULE

10:30 A. M. E. S. T. Inspection Trip of New Four High Mill
12:00 Noon E. S. T. Luncheon at Elk's Club, Salem, Ohio
Chicken and all the "fixens".....$1.00
1:30 P. M. E. S. T. Technical Session
"Cold Rolling Processes" by Lloyd Jones,
General Manager, E. W. Bliss Co., Salem, O.

RESERVATIONS MUST BE MADE FOR THIS TRIP.

HAVE YOU MAILED YOUR RESERVATION CARD?

TRANSPORTATION INFORMATION

RAILROAD

Fare $3.15 Round Trip from Pittsburgh. Be sure to ask for Week-End Ticket.

PITTSBURGH SECTION

Leave Pittsburgh	8:10 A. M.
Arrive Salem	9:39 A. M.
Leave Salem	6:38 P. M.
Arrive Pittsburgh	8:05 P. M.

CLEVELAND SECTION

Leave Cleveland	8:20 A. M.
Arrive Salem	9:56 A. M.
Leave Salem	6:32 P. M.
Arrive Cleveland	8:05 P. M.

PHILADELPHIA SECTION

Leave Philadelphia	10:35 P. M.
Arrive Pittsburgh	6:55 A. M.
Leave Pittsburgh	8:10 A. M.
Arrive Salem	9:39 A. M.
Leave Salem	6:38 P. M.
Arrive Pittsburgh	8:05 P. M.

CHICAGO SECTION

Leave Chicago	11:30 P. M.
Arrive Salem	9:35 A. M.
Leave Alliance	11:41 P. M.
Arrive Chicago	7:00 A. M.

AUTOMOBILE

From Pittsburgh take Route 30 to Lisbon, Ohio then Route 45 to Salem O.
From Cleveland take Route 14 to Salem, O.

EDITORIALS

OPENING THE DOORS OF INDUSTRY . . .

The Inspection Trip, which the A. I. & S. E. E. is conducting to the E. W. Bliss Company at Salem, Ohio, reminds one that for twenty-six years we have sponsored Inspection Trips to not only the Plants of the Iron and Steel Industry but to Industrial Plants who serve this Industry as well.

Over one hundred plants have been visited by the A. I. & S. E. E. The benefits and educational value of these trips are many: The opportunity for the executives of the Steel Plants to visualize in person the improvements in all Steel Mill Practices; The comparison of the methods of the various plants and the promotion of a better spirit of fellowship in the Industry.

Through the Association 30,000 executives, associated in one way or another with the Steel Industry, have been provided an opportunity to visit every major Steel Plant in the United States and Canada. The A. I. & S. E. E. are the pioneers of this movement and have helped to a large degree to "Open the Doors of Industry."

▲

STEEL CAMPAIGN TIME LENGTHENED . . .

Due to the deferring of the Annual A. I. & S. E. E. Convention and Iron and Steel Exposition until Fall, the Board of Directors of the Association have decided to extend the time of the closing of the New Uses for Steel Campaign from the original date of May 15 to the time of the Convention which will be held, tentatively, in late September or early October.

This extension of time in the Campaign will give every employee of the Iron and Steel Industry, who, due to the economic conditions has not been able to co-operate, an opportunity to contribute a suggestion in furthering the market for STEEL.

The Board of Directors appreciate the spirit of co-operation shown by the members in this Campaign. It is a healthy sign of real interest in the affairs of the Association.

TRAINING SUPERVISING FORCES . . .

The last eighteen months, due to the business situation, has brought out comparatively little new equipment, therefore, it can hardly be considered a period in which many new developments actually took place in the Industry. The various manufacturers, due to idle facilities, are taking advantage of the lull in demand for further developments.

Much of the equipment developed in the last three years has become very expensive in first cost due to the necessity of producing a product which will meet the demands of the trade. This equipment is, in a large number of cases, complicated from the standpoint of design and control.

The operation of equipment of this nature has, it is felt, brought out one major development in the last few years. This development is primarily the realization of the fact that the complicated equipment being built today can only be properly maintained by high grade skilled repairmen. The thought that must be kept in mind is that expensive complicated equipment, as is now being installed, must be maintained as nearly in one hundred per cent condition as possible if it is to function satisfactorily and if not so maintained, deterioration becomes excessive.

From past experiences it has been learned, to properly maintain modern equipment requires a certain supervising force capable of analyzing the complicated problems involved, and also capable of outlining a program of continuous maintenance whereby this equipment will be kept in 100% operating condition at all times. It therefore becomes imperative that maintenance work of this nature must be turned over to that class of repairmen who understand and appreciate their responsibility.

Many of the new installations represent investments for which entire steel plants could have been built, a few years ago.

These investments should be turned over to that type of repairmen who understand the art of thinking and analyzing and must be given training which will enable him to properly analyze the problems involved in the installation of the modern equipment in the Steel Industry today.

INDEX TO ADVERTISERS

A

The Alliance Machine Co. 148
Allis-Chalmers Manufacturing Company 142

C

Crocker-Wheeler Electric Manufacturing Co. 149
Cutler-Hammer, Inc. 145

E

The Electric Controller & Mfg. Co. 140

G

General Electric Company Cover 4

H

Hyatt Roller Bearing Company 146

I

I-T-E Circuit Breaker Company Cover 3

M

The Martindale Electric Co. 150
Mesta Machine Company Cover 1
The Morgan Engineering Company 147

P

Pennsylvania Transformer Company 151

R

Rockbestos Products Corporation 144

S

Schloemann Engineering Company 141
SKF Industries, Inc. 143
Stimple & Ward Co., Inc. 151

T

The Timken Roller Bearing Co. 152
The Tool Steel Gear & Pinion Co. 150

W

Westinghouse Electric & Mfg. Company Cover 2

Boiler Water Conditioning With Alumina and Magnesia

By W. F. PETERS, JR.
Water Engineer, Pelham, N. Y.

The treating of boiler feed-water with magnesium bicarbonate or sulphate and sodium aluminate, or its more recently developed colloidal oxide of alumina is a new development that has been successfully used for the past two years under the direction of the author. It is the result of considerable experimenting along original lines and had its inception in the idea of keeping down chemical costs, with lower boiler alkalinity to maintain a better sulphate ratio so as to prevent caustic embrittlement, and insure a freedom from the action of soluble or colloidal silica.

The plant at which this treatment was first employed is located in the country, off the main highway, and manufactures heat-insulating products. The quarry is located alongside the plant. The geology of the country rock is chiefly dolomite. The magnesia is the chief value of the rock, and is recovered for use in heat-insulation products.

Water Supply.—At this point there are two sources of water supply available. From a fissure in a quarry there flows a strong well-defined stream that necessitates the use of pumps to keep the quarry dry. A small concrete basin has been built to impound the water and make it easier to collect for pumping. The general system in use was to pump the quarry water and well water into two large tanks outside of the boiler house and from them draw water for both process and boiler work. Any deficiency in quarry water is made up by water pumped from a deep driven well. It was not advisable to use well water exclusively for boiler purposes, for at times excess quarry water had to be pumped to keep the pits dry, and unless used, this pumped water represented waste. At such times, any well water pumped would increase the overall operating cost.

Analysis.—The first source of water pumped from the quarry gave an analysis as shown in Table 1.

TABLE 1.—QUARRY WATER

	Previous Analysis	Peters Analysis	
G. P. Calcium hardness	7.0	7.1	g.p.g. as $CaCO_3$
H-GP Magnesium hardness	7.3	7.4	" " "
M Methyl Orange Alkalinity	13.4	13.4	" " "
H Total hardness	14.3	14.5	" " "
CO_2 Carbon dioxide	1.0	2.0	" " CO_2
Cl Chlorides	0.6	0.8	" " NaCl
SO_4 Sulphates	1.6	3.0	" " Na_2SO_4
NO_3 Nitrates	3.0	3.0	" " $NaNO_3$

The second source of water is a deep driven well about 700 ft. below the quarry level and strange to say, the water is much softer and better for boiler purposes. An analysis is shown in Table 2.

TABLE 2.—WELL WATER

G.P. Calcium hardness	5.3	g.p.g. as	$CaCO_3$
H-G.P. Magnesium hardness	4.4	" "	"
H. Total hardness	9.7	" "	"
M. Methyl Orange Alkalinity	8.6	" "	"
CO_2. Carbon dioxide	.07	" "	CO_2
Cl. Chlorides	.05	" "	NaCl
SO_4. Sulphates		" "	Na_2SO_4

From these tanks the water was pumped a lime and soda softener with a center mixing chamber and flowing into the outer chamber to allow the sludge to settle to the bottom and the clear water to flow off the top. This softener was of the semi-hot type. A typical analysis of the water from the heater before starting the new method was:

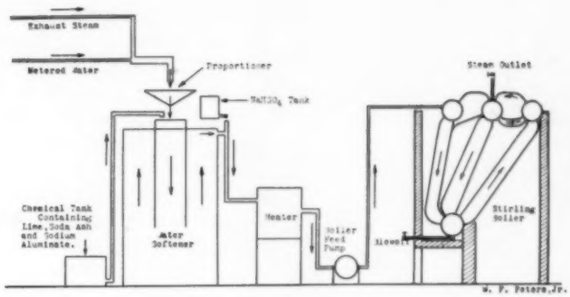
H 4.1 P 1.0 M 3.0 Cl 2.9

Along with the treated water from the softener, the returns are fed into a open type of feedwater heater. A typical analysis of this water was:

H 0.5 CO_2 0.2 M 3.5 Ph. 6.8

The water is then fed into the boiler by a centrifugal pump. A typical analysis of the boiler water was:

H 2.0 P 7.6 M 9.0 Cl 17.6



Schematic Diagram of System.

New Boiler Plant:—The new boiler plant consisted of a 1044 hp. Stirling type of boiler, stoker-fired, with water-cooled sidewalls, but without a super heater. A continuous blowdown attached to the center drum is used to keep the concentration down, and a heat reclaimer is used to recover as much of this waste heat as possible. The boiler was continuously operated at 220 per cent of rating at 200 lb. pressure and usually evaporated 1,600,000 lb. or more, of water per 24 hours. The load has been fairly evenly distributed. The steam was bled from the turbine at 135 lb. and used for process work.

The water softener.—The water softener consisted of a tank about 15 feet in diameter and about 25 feet high, and stood in the open between the old and new boiler houses. The mixing or chemical tank was located in the old boiler house. The solution was kept in motion by a continuously operated paddle. A pump raised this solution into a small basin at the top of the water softener, the excess or overflow returned by gravity to the mixing tank. One of the difficulties was that the measuring buckets on top of the softener would not always dump with the same amount of water. When the raw water flow was slow, less water would be measured, per bucket, than when it was fast. The temperature of the water in the softener was from 120 to 140 deg. fahr.

Changes to softener.—The first change was to place a meter in the raw-water line to determine the daily water consumption. This was found to be about 150,000 to 160,000 gallons. As there was excess steam going to waste, it was piped over to the

softener and an injector type of fitting was used to heat the raw water after leaving the meter and before measuring by means of the buckets. The outside of the softener was lagged to retain the heat, with the result that the temperature of the water rose to 180 to 205 deg. fahr. and on some occasions 210 deg. was maintained. The chemical feed was not changed, it being regulated by the dumping of the buckets. The chemical was charged every 12 hours, making a thinner solution and more easily controlled solution than the 24-hour charge did.

Scale.—Previous treatment had resulted in insufficient softening of the water so that the boiler had scale in varying amounts. It was turbined every 14 weeks as a precaution. While this was being done, a battery of six older, lower-pressure boilers was used. The general results were not satisfactory and a new method of treatment was decided upon.

New Method Employed.—It was decided to try a certain make of liquid sodium aluminate, the sodium aluminate content of which was about 7 per cent. Later, another make, a liquid with 32 per cent was tried. This was much more effective. Still later other forms were tried. Along with this, lime and soda ash were used. The two water tanks previously referred to were separated. The quarry pump discharged into one, the overflow ran into the second. The deep well pump fed into the second. In this way the boiler was fed with quarry water and the process would use well water to make up any deficiency of quarry water which might occur. Daily tests were made of the quarry water and the results showed practically no change under varying weather conditions. This was also true of the well water. Treatment was started to reduce the softened water to zero soap-test hardness. A 12-hour charge of 37½ lb. of sodium aluminate, 225 lb. of hydrated lime, 40 lb. of soda ash were used and a typical reading taken of this softened water showed:

	H	G.P.	P	M	Cl	SO_4
From softener	1.4	0.9	1.5	3.0		
From boiler	0.3		40.5	43.8	7.2	12.0

From these tests it was shown that the alkalinity-sulphate-ratio was not kept up. Instead of being at least 2 to 1 or 1½ to 1, it was 1 to 3 or 1 to 3½, etc. This clearly called for corrective treatment so that a case of caustic embrittlement would not occur. To do this, Glauber's salts or sodium sulphate were added and a test run made. It was not deemed advisable to add the full amount of sodium sulphate. A 12-hour charge of from 10 to 20 lb. of Glauber's salts was put in at the heater to bring up the sulphate ratio. The results of this run are shown in Table 3.

TABLE 3

	H	P	M	Na_2SO_4
1	0.0	20.4	24.2	17.5
2	0.0	66.0	73.0	47.0
3	0.0	62.0	69.6	50.0
4	0.0	60.8	67.6	51.0
5	0.0	60.0	66.0	53.0
6	0.0	61.0	66.8	56.0
7	0.0	62.0	64.8	59.0
8	0.0	66.0	70.8	62.0
9	0.0	74.0	80.4	68.0
10	0.0	90.3	96.8	
11	0.0	53.2	60.0	42.0
12	0.0	46.0	52.0	49.0
13	0.0	50.0	53.4	71.0
14	0.0	49.0	53.2	65.0
15	0.0	33.6	38.4	42.0

From this chartered run, it was evident that considerable more blowdown was necessary to maintain a lower alkalinity, and also more than 20 lb. of Glauber's salts was needed to maintain the sulphate ratio. On the eleventh day, the amount of blowdown was considerably increased, and with this increase the alkalinity went down and a ratio of about 1:1 was held.

Aside from the additional material required for this method of treatment, a further hazard was the peptizing action of this water with the calcium sulphate and sodium carbonate, with a resultant formation of scale. The quality of steam was poor, and a constant watch was maintained for carryover of moisture. This method of treatment was expensive due to the higher cost of chemicals and to the fact that the greater amount of dissolved solids in the boiler necessitated an increase in blowdown with a corresponding increase in fuel cost. A radical change in treatment was decided upon after referring to "Elements of Physical Chemistry," by J. L. R. Morgan. The following excerpt from pages 151 and 152 is quoted, as the book is out of print: "An experiment which shows in a particularly striking way the possibility of supersaturating a liquid with a gas is the following: Allow carbonic water from a charged syphon bottle to flow into a glass which has been wiped clean. At first a violent bubbling will be noticed, which, however, will soon cease, leaving the liquid in a state undistinguishable from distilled water. That the liquid is in reality very greatly supersaturated with the gas, though, can be shown here, even hours later provided it be protected from the dust floating particles in the air, by dropping into it a piece of chalk, or fragment of any other porous substance, when the gas will be evolved so violently from the solid matter, that it will be carried bodily to the surface by the bubbles. Ostwald found in such a case that the CO_2 pressure in the apparently pure water could be retained at an internal pressure as high as two atmospheres, even though the counter external pressure was atmospheric. The original pressure in a syphon bottle is usually about five atmospheres."

A careful study of this paragraph led to further thought and research. Wherein was this like and unlike boiler action. To begin with, both were saturated solutions, both reactions could take place under pressure, the boiler had about 15 atmospheres instead of the one. The boiler had heat. Would the addition of this material cause foaming or would it produce a smaller steam bubble? Were there any additional atmospheres that were causing the steam and water to separate slowly, thus causing a large steam bubble. Would this be called surface tension? Did suspended solids adhere to the surface of the steam bubble and cause dirt to go over into the steam? Niehaus in his paper "Physico, Chemical Considerations of the Problem of Boiler Water Foaming" emphasizes that the size of the particles is a factor in the stabilization of foam by suspended solids. He puts this size as lying near the border of colloidal and gross dispersion. It is also known that "Numerous metallic oxides are insoluble in water and form colloidal oxides when their salts are hydrolized." Sol of the oxide of alumina is one of these and is prepared by the dialyzing the salt, dissolved in water against water." Fine chalk caused

the carbonated water to bubble and coke seemed to cause even more violent bubbling. From another case, it was found that a calcareous scale if removed too quickly would cause foaming. Therefore in considering all these angles, the possibility of floc formation seemed to be the solution. Then, in further, considering this floc, why would it not be better if it were of a colloidal nature. The ultimate and most successful aluminate proved to be one high in the colloidal oxide alumina. It was also desirable to produce a size of steam bubble that would prevent the violent bursting at the water surface. Further, it was believed that the coagulant nature of alumina would be beneficial in producing a bubble of this character. It would have a tendency to coagulate the fine particles and prevent them from carrying over with the steam bubbles. It is also a well-known fact that the velocity of water through a tube is not constant at all points in the tube. The velocity next to the wall is slower than the velocity in the center due to skin friction. A steam bubble would naturally form at the surface of the tube and go along in the faster traveling part of the stream.

It is also known that the magnesium bicarbonate on heating breaks down into magnesium hydroxide which is a very insoluble and flocculent precipitate. With proper alkalinities, magnesium sulphate would also do the same. It was also noted that calcium bicarbonate would readily react to the addition of calcium hydrate and quicker than the magnesium bicarbonate as this is the basis of the commercial calcium and magnesium separation, and that sodium aluminate would accelerate this reaction.

From these facts it was decided to treat the water in the softener with less lime, and possibly less soda ash and sodium aluminate, and carry over into the boiler a negative or bicarbonate reading, instead of a positive or hydrate reading. This would reduce hydrates and ought to increase the sulphates in the boiler water. Accordingly, the charge was reduced to lime 90 lb. soda ash 40 lb. and aluminate 32½ lb. Exactly what was expected did happen. The readings were as follows:

	H	P	M	SO_4	2P—M
Softener	5.8	1.0	6.7		—4.7
Boiler	0.0	14.4	20.0	38.0	

It was also found that if the 2P—M reading was less than between —3.0 and —4.0 and more than —8.0 the water from the softener was not clear but milky. Therefore it was decided to run the water with this reading from —5.0 to —7.0. A series of tests were then run using from 10 to 20 lb. of Glauber's salts twice daily. From these tests it was evident that a better quality water could be maintained at a lower cost and therefore a saving could be effected. The results are tabulated in Table 4.

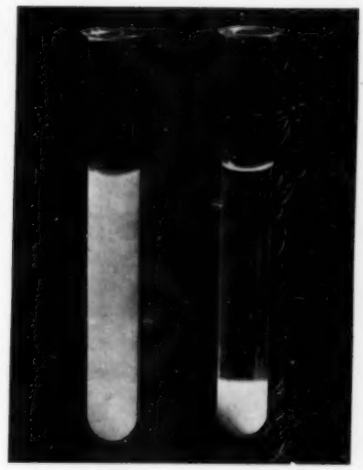


FIG. 1.

TABLE 4

	H	P	M	Na_2SO_4
1	0.0	5.2	6.7	17.0
2	0.2	11.7	13.5	28.0
3	0.1	9.7	12.1	30.0
4	0.0	19.6	24.0	37.0
5	0.1	24.1	26.7	42.0
6	0.2	27.2	29.7	41.0
7	0.1	21.1	22.6	32.0
8	0.1	20.0	21.6	27.0
9	0.0	21.0	22.6	27.0
10	0.1	21.1	23.0	28.0
11	0.1	23.9	26.0	29.0
12	0.0	22.6	24.3	27.0
13	0.1	22.5	24.7	28.0
14	0.1	24.5	27.3	37.0
15	0.2	29.3	32.3	40.0

In figure 1 a photograph of the boiler water is shown, the test tube on the left, as it comes out of the boiler with its milky appearance. The one on the right is the test tube after standing 15 minutes. An analysis was made of the floc and its probable combinations. The silica and alumina were not combined.

Silica	SiO_2 and insoluble	1.55%
Magnesia	MgO	47.50%
Lime	CaO	15.50%
Alumina	Chiefly Al_2O_3 (R_2O_3)	1.50%

Probable Combinations:

Silica	SiO_2 and insoluble	1.55%
Calcium carbonate	$CaCO_3$	27.60%
Magnesium hydroxide	$Mg(OH)_2$	68.50%
Alumina, etc.	R_2O_3	1.50%
		99.15%

A sample of the floc was put on a slide and examined under a microscope. Both an Abbe condenser and a dark field condenser were used. There apparently was some crystalline character to the precipitate but undoubtedly this had been broken by the violent action in boiler. By carefully arranging the cover glass, and the use of dilute hydrochloric acid, it was possible to observe the attack upon, and solution of, these crystals with a final clearing. There was some evolution of gas as bubbles were formed. Unfortunately, a sample of the original treatment as taken from the continuous blowdown had not been analyzed. It was, of a coarse granular nature, a typical carbonate deposit. The blowdown water did not clear as rapidly, nor was it as mobile as the new aluminate and magnesia floc. Previously, an analysis

of the scale before the aluminate magnesia method was installed, had been made. An analysis of the sludge at the bottom drum of the boiler was made as a comparison. This is shown in Table 5.

TABLE 5.

Using Aluminate		
Boiler sludge	Weights	Probable combinations
SiO_2 and insoluble	.0410	4.10% as such
R_2O_3	.0210	2.10% " "
CaO	.1515	27.00% " calcium carbonate
MgO	.4520	65.25% " magnesium hydroxide
Using no aluminate		
Old scale	Analysis	Probable Combination
SiO_2	5.88%	calcium silicate 10.35%
R_2O_3	2.26%	calcium carbonate 74.61%
CaO-lime	49.80%	calcium sulphate 5.53%
MgO-magnesium	5.07%	calcium oxide unaccounted for 0.67%
CO_2-carbon dioxide	32.87%	magnesium hydroxide 7.35%
SO_3-sulphur trioxide	3.26%	alumina 2.26%
Loss on ignition	1.28%	
	100.42%	100.77%

As we compare the two, a complete reversal of treatment is noted. The sludge had a heavy magnesia content as against the heavy lime content of the scale. In the sludge the ratio of magnesium hydroxide is 2¼ times the calcium carbonate content. In the scale there is 10 times as much lime as magnesium. The silicia content of the scale was higher than the sludge. This again bore out the theory. At this point, filtered samples of boiler water and softened water were examined to see if the alumina was in the colloidal form. It was found upon examination with the use of the dark field condenser that the Brownian movement was present, although no attempt was made to measure the size of the colloidal particle. This movement is the irregular zig-zag line, to and fro, often rushing across the illuminated field of view, as though it were a living object and then vanishing.

To reduce the boiler alkalinity further, it would have been advisable to add sulphuric acid, but this is hard to handle, and requires expensive equipment. Sodium bisulphate was tried by dissolving 10 lb. in an earthenware crock. A 3/16 in. glass inverted "U" tube was devised so that it would feed just the right amount of solution. This was run into the filtered water. The result was lower boiler alkalinity and a higher sulphate reading. This ran 12 hours. It was found that 30 lb. of sodium bisulphate at 0.7 cents per lb. would do the work of 60 lb. of Glauber's salts at 1.0 cents per lb., an appreciable saving.

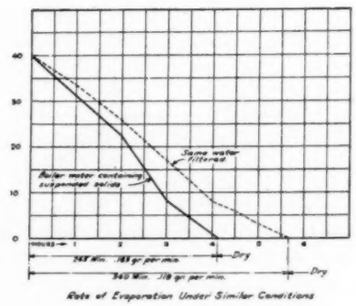
As a final test of the beneficial results of the floc, equal amounts of blowdown samples were evaporated to dryness at various rates. In one dish a filtered sample would be used, and alongside it would be put a sample of equal weight containing the suspended solids. In practically all the cases, quicker evaporation was obtained from the sample containing the floc. This seems to bear out the idea of the colloidal action of the alumina.

In figure 2 is shown a curve of comparative slow evaporation, on a water bath. The floc sample evaporated at 0.163 grains per minute, while the clear sample showed 0.118 grains per minute.

Quality of steam.—All through these tests, using sodium aluminate, the calorimeter did not show more than ¼ of 1 per cent of moisture at 200 per cent of rating. It was then decided to see how the percentage of moisture in the steam would be affected by high alkalinity and concentration. The blowdown was closed and when the following readings were obtained the calorimeter was read:

H 0.0 P 166.0 M 184.0 Cl 23.6
Evaporation of 40,000 lb. showed 1.25% moisture
" " 60,000 lb. " 1.30% "

FIG. 2.



Previous to the sodium aluminate test run, the boiler was turbined, and as much scale as possible removed. It was customary to turbine this boiler every 14 weeks. Upon taking the boiler off the line after 7 weeks of using sodium aluminate there were appearances of scale removal. Also, the boiler looked as though it had been white-washed. Later on the time of outage was increased so that the boiler was taken off the line only for repairs. The internal appearance was always that of a white-washed boiler. A fire hose would wash it clean, and gradually, most of the scale came off. After two years of service a turbine was run through the tubes. There was less than 50 lb. of scale in the whole boiler. During that time, over two carloads of encrusting solids in the raw water had been removed. In addition, an examination disclosed that, even though there was no superheater on the boiler that the blades of the turbine were clean.

A comparison of treated and boiler water at this point is most interesting. It shows that in most cases, the suspended solids are greater than the dissolved solids. However, at no time did the colorimeter show more than ¼ of 1 per cent of moisture. Usually in such cases of suspended solids, there is

carry-over, particularly where there is more than 1 to 1 ratio of dissolved to suspended solids. Table 6 shows ratio of 1 to 3.4 which in almost every case would mean carry-over, yet there was none.

TABLE 6.

Source	pH	H	P	M	Cl	Na_2SO_4	NaOH	2P-M	Total Solids	Soluble Solids	Suspended Solids	Concentration
Treated	7.5	8.6	1.4	9.0	1.2			6.2	14.6	13.2	1.4	
Boiler	10.0	0.0	19.4	23.0	7.0	44.5	12.6	15.8	211.0	85.0	126.0	5.8
Treated	7.4	5.6	1.4	7.4	1.2			4.6	5.85	5.85	0.0	
Boiler	10.0	0.0	21.2	25.2	6.8	44.5	13.5	17.2	307.0	82.0	225.0	5.65
Treated	7.6	5.4	1.5	7.4	1.2			4.4	27.0	12.0	15.0	
Boiler	10.2	0.0	28.2	32.6	8.0	43.0	19.0	23.8	320.0	102.0	218.0	6.65
Treated	7.6	5.8	1.5	8.1	1.2			5.1	17.5	14.5	3.0	
Boiler	10.0	0.0	26.4	32.0	8.2	45.0	16.5	20.8	300.0	102.0	198.0	6.8
Treated	7.6	7.0	1.2	8.3	1.3			5.9	14.0	13.7	0.3	
Boiler	9.7	0.0	21.4	25.0	7.5	47.0	14.0	17.8	224.0	96.5	127.5	5.75
Treated	7.6	5.8	1.3	7.4	1.4			4.8	11.7	8.8	2.0	4.60
Boiler	10.0	0.0	14.6	17.2	6.4	41.0	9.6	12.0	127.5	76.5	51.0	
Treated	7.6	9.0	1.3	10.1	1.8			7.5	35.0	15.0	20.0	
Boiler	10.0	0.0	21.1	25.8	8.8	48.0	13.0	16.2	438.0	99.0	339.0	4.88
Treated	7.6	6.2	1.2	7.9	1.4			5.5	12.3	11.7	0.6	
Boiler	10.0	0.1	16.0	19.2	6.2	37.0	10.24	12.8	136.0	69.7	66.3	4.43
Treated	7.4	6.0	1.3	7.5	1.3			4.9	8.75	7.3	1.5	
Boiler	9.8	0.1	11.2	13.6	5.4	29.0	7.0	8.8	102.5	61.8	41.0	4.15

The figures in the concentration column are found by dividing the chlorides in the boiler water by the chlorides in the treated water.

Sodium Aluminates.—In all, there were five different kinds and makes of sodium aluminate tried. No. 1 was a liquid aluminate of about 7 per cent strength. This evidently was not suitable as the amounts suggested by the manufacturer did not yield the results. It was afterwards determined that at least 140 lb. per day would be necessary.

No. 2 was a liquid of about 32 per cent strength and from tests required 65 lb. daily. This was very efficient and gave good results.

No. 3—This aluminate was a dry aluminate of 65 per cent content but it was most difficult to liquify and if introduced direct, a sulphate coating formed on it and no further dissolving could occur. For this reason it was abandoned.

No. 4—This aluminate was also a dry one of 77 per cent content and had to be dissolved first to prevent sulphate coating. It was effective and reduced the aluminate to 40 lb. per charge. This had the difficulty of hardening the filter bed surface and had too much insoluble material.

Colloidal Oxide of Alumina.—This material was originally called Sodium aluminate paste of only 39 per cent content although it is practically dry. It reduced the charge to 38 lb. per day. This material was produced, first in the laboratory of a large chemical company under the direction of the author. It did not cause any hardening of the filter bed surface and gave better results. From the microscopic slides, it appears to be high in the colloidal alumina oxide content, and not a simple chemical.

Method of testing.—Rapid and reasonably accurate methods of testing were used. The soap test is the method used for hardness. The solution is so calibrated that it will read in grains per gallon on a 58.3 cc sample. There are 58,333 grains in a gallon. With this test there are two end points. The first lather is called the "Ghost Point" or calcium hardness, noted as G.P. The reason is that calcium salts will give a lather sooner than magnesium, and when the soap starts to react with the magnesium, this lather will disappear. This lather is not a permanent one, and is often mistaken when this method is used. Continuing we get the permanent lather that will stand for five minutes, and this is the total hardness, noted as H. To get the magnesium, we subtract the calcium from the total, and this gives us all the results in terms of calcium carbonate. To get the real amounts of the hardness, as say, magnesium sulphate, we must multiply by a factor.

For the alkalinity test, two indicators were used. A solution of N/50 sulphuric acid is used to titrate the water, first with a phenolphthalein indicator, and then continuing without subtracting the amount and using methyl orange as an indicator, and the final or total alkalinity is found. A 58.3 cc sample is used and read direct into grains per gallon. The phenolphthalein colors the boiler water pink and into deeper shades provided the ph is over 8 and the endpoint is sharp, it must be run quickly to prevent flashback. This gives the P reading. The addition of methyl orange gives a yellow or straw color which on the addition of more sulphuric acid, turns first orange, then red orange. The ph at the orange point is 4, and the point is called the M reading.

Various manufacturers designate the term 2P-M with another letter. However, this is not necessary. When 2P-M is positive it is a combination of hydrate and carbonate, when it is negative, a combination of bicarbonate and carbonate.

The silver nitrate is roughly a N/56 solution which will read direct to grains per gallon as sodium chloride. A neutral potassium chromate is used as an indicator. To make this test, the P reading is run, then immediately followed by the chromate indicator and the titration with silver nitrate. The Benzidine method was used as the test for sulphates. This is accurate and quick, provided the benzidine sulphate is washed free of the chloride. In doing this the boiler water was almost neutralized with hydrochloric acid dilute, as the solution will filter much more readily and less liability of chlorides being entrapped in the precipitate. The usual tests for silica and nitrates were run, supplemented by the use of the Hellige apparatus. This consists of various discs which enable one to colorimetrically determine the amounts present.

Conclusions.—In previous treatments it had been the aim to reduce the hardness in the water to place in the boiler a very soft water. It was thus found that by increasing the magnesia hardness in the treated water, the resultant water would not only be soft, but the magnesia alumina combination would eliminate the silica to a greater extent and prevent it forming a binder for the calcium scale. As proof of this, the analysis of the sludge showed twice as much alumina ratio to silica as that of the scale. Also, the old scale had 13 times more lime than magnesia while in the sludge, the magnesia was 2¼ times that of lime, a complete reversal of form.

If the theory is accepted that scale is formed in place it must be the combination action of the colloidal alumina and the magnesia that is preventing it. As boiler tubes usually have scale the entire length, and the water is evaporated throughout the entire length, it is only reasonable to suppose that this action is taking place not only through these tubes but also in the drums as they were also clean. This conclusively showed the benefit of the non-adhering, flocculent material as against the heavy non-flocculent calcium precipitate. The direct result was that after a period of two years operation, there was less than 50 lb. of scale which might have been entirely free, had there been a better and more accurate proportioning device. It is also reasonable to assume that the floc on circulating is subject to changes in temperatures and does act to assist in the giving off of the steam in a free form, due to this. The alumina evidently has a great deal to do with the prevention of scale as the resulting sludge has less silica than the scale.

As there was no carry over of moisture it is reasonable to assume that the nature of the suspended solids must be a factor in carry-over. It is evident that the flocculent precipitate collects or entraps other suspended solids and prevents carry-over of these particles. It is also evident that the nature of the floc must also act as a reducer of the surface tension and thus permit the easier escapement of steam, and probably the retention of heat by the floc has a great deal to do with it. Also the colloidal oxide of alumina is an alkaline solution in the production of this special type of floc, undoubtedly permits the reaction to take place much more easily.

The author gratefully acknowledges the assistance of the chemist in charge, Mr. Joseph Shrawder of Mont Clare, Pa., who has been of great help and advanced some of the theories developed.

To the Officers and Committees of the District Sections,
Association of Iron & Steel Electrical Engineers:

The President and Board of Directors of the Association of Iron & Steel Electrical Engineers desire to extend to you their sincerest appreciation for your magnificent efforts in making your Sectional activities so successful during the past year. You are to be congratulated on your technical programs, your wonderful attendance at your meetings and your interest in your Association's activities during these trying economic times.

Your National Officers appreciate your splendid co-operation and likewise, many of the presidents of the Steel Plants have expressed themselves as being particularly well pleased with the Association's efforts in the Steel Industry's behalf during the past year.

It is your Association's ambition to render a still greater service to the Steel Industry in every manner possible and with this end in view, let us review the past and plan diligently for the future.

Yours very truly,

A. I. & S. E. E.,
J. D. DONOVAN, *President.*

The Application of the Synchronous Tie To Modern Control Problems

By R. H. WRIGHT
Steel Mill Engineer, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

Presented before the Pittsburgh District Section of the A. I. & S. E. E., December, 1932.

The synchronous tie may be defined as an electrical device for reproducing motion or transmitting power with no mechanical connection between driving and driven units. A number of schemes for synchronizing two or more independent shafts electrically are in use. The discussion in this paper will be limited to the scheme which employs two induction motors with interconnected secondary windings and this scheme will be considered as the true synchronous tie.

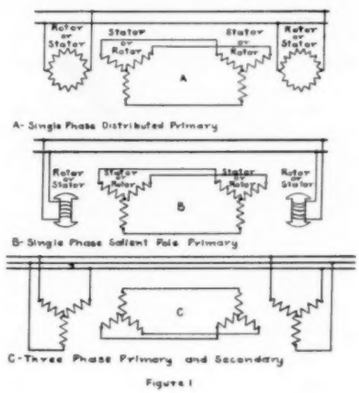


Figure 1

FIG. 1.

The principle of operation of the synchronous tie, as defined above, is not new, but it is only recently that it has been applied for transmitting appreciable amounts of power. The speed-torque characteristics have not been discussed widely. A brief discussion of the characteristics and field of application of the synchronous tie therefore forms the material for this paper.

In this discussion no effort will be made to go into the details of design of the synchronous tie or to explain the theory of operation. These phases of the subject can be developed at great length where time permits. The aim is rather to indicate the general operating characteristics and to show the wide range of applications for which it can be used.

It is well known that if two similar induction motors, having polyphase secondaries, have their primary windings excited from a common source and the secondaries electrically connected; neither motor will rotate unless the other is rotated by some external means. Any movement of one rotor will be duplicated by the other, within certain limitations. Three forms of the synchronous tie system are shown in Figure 1. When used for position indicators and similar applications not requiring heavy torques it has been customary to use motors with single phase primary windings. The primary winding may be either a distributed winding or a salient pole winding. Each type of winding has peculiar characteristics. As the size of the machines is increased the vibration set up by the single phase exciting winding may become objectionable. Vibration is reduced to a minimum by the use of three phase windings for both primary and secondary and by exciting both machines from a three phase line. This arrangement also has the advantage that the machines are of standard construction.

Typical torque characteristics at standstill of the three forms of synchronous tie shown in Figure 1 are given in Figure 2. It will be noted that in all cases there must be some angular movement of the transmitter before any torque can be exerted by the receiver. The angular displacement between transmitter and receiver is greatest for a system having motors with single phase distributed primary windings. As shown by Curve A, Figure 2; the maximum torque for such a system occurs at about 140° displacement of the transmitter. Curve B, obtained with two machines having salient pole primary windings in the stators, shows considerable improvement over Curve A. The torque rises rapidly with the angular displacement and reaches a maximum at 110°. The torque is the same for either direction of movement with single phase excitation. Curve C shows the torque for two machines with three phase primaries. The torque rises rapidly with the displacement. The torque in one direction is greater than in the other and in the direction of least torque the maximum is reached sooner. However, in the direction of least torque the torque is equal to or

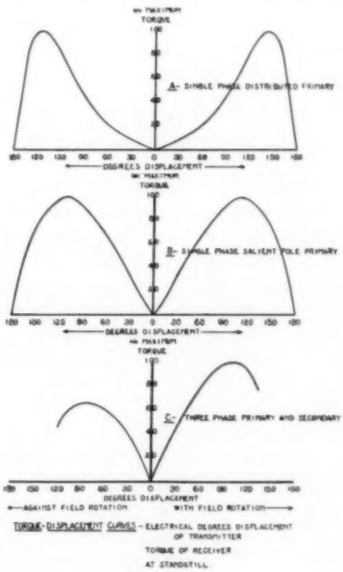


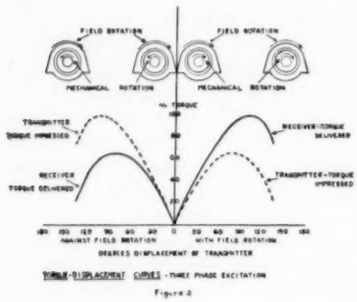
Figure 2

FIG. 2.

THE PROTECTIVE TARIFF WAS NEVER NEEDED MORE THAN IT IS NOW

greater than the torque obtained with single phase excitation, for the same size machine. In the other direction the torque at standstill is considerably greater than with single phase excitation.

The curves shown in Figure 2 are typical. The shape of the torque curves will vary with the size and design of the machines and with the proportions of resistance and reactance in the secondary circuit. Prediction of the torque characteristics by calculation is rather difficult for machines with single phase excitation but is comparatively simple for three phase machines.



TORQUE-DISPLACEMENT CURVES - THREE PHASE EXCITATION

Figure 2

FIG. 3.

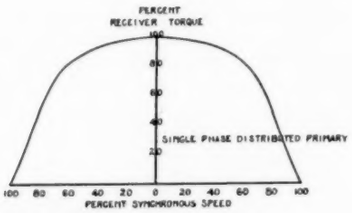
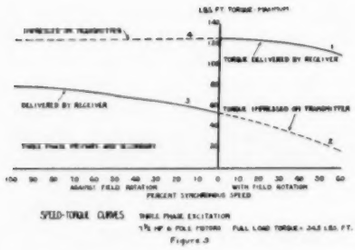


FIG. 4.

SPEED-TORQUE CURVES SINGLE PHASE EXCITATION

Figure 4



SPEED-TORQUE CURVES THREE PHASE EXCITATION

Figure 5

FIG. 5.

With single phase excitation the receiver torque at standstill is equal to the transmitter torque minus the losses. This makes the torque exerted by the receiver practically equal to the external torque imposed on the transmitter. With three phase excitation the receiver torque and transmitter torque at standstill are not the same. The curves of Figure 3 show the torque relations at standstill in a three phase system. It will be noted that with external torque applied in the direction of the rotating field of the stator, the torque exerted by the receiver is greater than the torque impressed on the transmitter. When the external torque is applied in the opposite direction, the torque at the receiver is less than the torque impressed on the transmitter.

Before the synchronous tie can be applied to the transmission of any appreciable amount of power, the speed-torque characteristics must be studied. When the transmitter is rotated, which in turn causes the receiver to rotate, the standstill torque relations between them no longer exist. This is true whether the excitation is single phase or polyphase.

Figure 4 shows the results of a speed-torque test on a synchronous tie with single phase excitation.

FIG. 6.

It will be noted that after a speed equivalent to about two thirds of the synchronous speed is reached, the receiver torque falls off rapidly.

When the system is rotating, the transmitter and receiver torques are not the same. The transmitter torque is less than the receiver torque in either direction of rotation.

In Figure 5 are shown curves for a synchronous tie consisting of two three phase machines. When the mechanical rotation is in the direction of the field rotation the torque which can be exerted by the receiver is greatest, as shown by the solid line curve 1. However, this receiver torque is available only under steady load and speed conditions. A sudden drop in speed of the prime mover and transmitter may cause the receiver to become the transmitter momentarily until the stored energy of the load has been equalized. The equalizing torque which can be transmitted back to the prime mover is quite limited, as shown by the Curve 2. This curve, then, indicates the synchronizing power when mechanical and electrical rotation are the same. Therefore, for variable speed operation where there is considerable flywheel effect at the receiver and little friction to absorb variations in kinetic energy, Curve 2 is the true indication of the load which can be transmitted safely when mechanical rotation and field rotation are in the same direction.

As indicated by Curve 3, when mechanical rotation of transmitter and receiver is opposite to the field rotation, the receiver torque is reduced but does not fall off with increased speed. Also, as shown by Curve 4, Figure 5, there is no loss of synchronizing power when the torque is suddenly reversed without reversal of rotation. For this reason, where the three phase synchronous tie is operated in one direction only, the direction of mechanical rotation should be against the direction of field rotation. When the system operates in either direction and is subject to overhauling loads, the motors must be of such size that ample torque is available to transmit reverse torques when mechanical rotation is the same as electrical field rotation. The inertia of the receiver and load and the rate of acceleration and deceleration must be studied carefully in determining the torque requirements. In some cases it is possible to reverse the primary leads when rotation is reversed, thus making the maximum synchronizing torque available in either direction and reducing the size of the machines to the minimum.

If the synchronizing torque of the system is exceeded in operation, either due to excessive load or excessive speed the transmitter and receiver fall out

of step. As a result the receiver usually runs as a straight induction motor or, "runs away". In applying the excitation to three phase machines, the control is usually arranged so that the circuits to all three power lines are not closed simultaneously. Otherwise the receiver or both machines may start and run as induction motors. The inductance of the leads between motor secondaries must be kept as low as possible. The electrical characteristics of the transmitter and receiver must be as nearly alike as possible.

The applications for the simple synchronous tie, consisting of a transmitter and receiver, are very numerous. Perhaps the most familiar application is for remote indicators which will enable a single operator to observe the operation or check the adjustments of a number of devices at the same time. A continuous strip mill, for example, has a number of vertical and horizontal screwdowns. Except for minor adjustments to correct for mill variations, all screwdowns could be adjusted from the mill pulpit if suitable indicators were provided in the pulpit. The operators could then make speed adjustments quicker and more accurately. Another typical application of this type is the indicator for a shear or saw stop. In some cases an operator rides on the stop and checks adjustments by means of marks on the carriage or by a tape and indicator. A synchronous position indicator will make it possible to make such adjustments from a central control point. Two equipments of this type are in operation in a Chicago mill.

It is not always convenient to connect simple overtravel or automatic sequence limit switches to machines mechanically. Seven automatic screwdown limit switches similar to those shown in Figure 6 have been installed with synchronous drive. While the friction of these limit switches is small, the inertia is considerable and the rate of acceleration of the screwdown motors, to which the transmitters are connected, is very rapid. The transmitters and receivers therefore have high pull-out torques as straight induction motors. An automatic screwdown under construction for a three high roughing sheet mill has the limit switch mounted on an operators pedestal and driven by synchronous tie.

Position indicators and limit switches usually do not require high continuous torque. However the synchronous tie may be used to transmit considerable amounts of power. For example, a lift bridge may be operated by synchronized drive, as shown schematically in Figure 7. If the two ends of the bridge are not lifted and lowered in synchronism, there is a tendency for the ends to bind in the guides. In such installations it is customary to have a main motor on each end of the bridge and to use the two units of a synchronous tie to insure parallel operation of the main motors, thus eliminating a mechanical tie. Such drives are usually designed so that if one main motor fails, it would be possible, as an emergency measure, to transmit sufficient power through the synchronous tie, by overloading the remaining main motor, to operate the two cable drums in synchronism.

Another variation of the synchronous tie is shown in Figure 8. In this arrangement each machine acts as a motor, drawing power from the line, but is held in synchronism with the other machine through the parallel secondary connection. An installation of 2-100 HP. motors has been used in this manner to operate the screwdown mechanisms for the vertical rolls of a universal slabbing mill. By this means considerable gearing and shafting is eliminated between the two screwdown mechanisms. The motors have two phase primary windings. Single phase excitation is maintained all the time the mill is in operation so the motors will not drift out of synchronism when idling or during reversal.

FIG. 7.

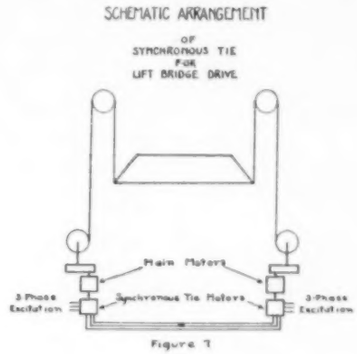


Figure 7

FIG. 8.

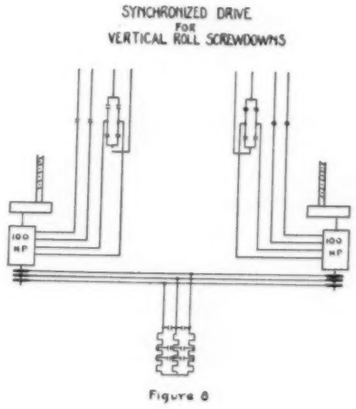


Figure 8

FIG. 9.

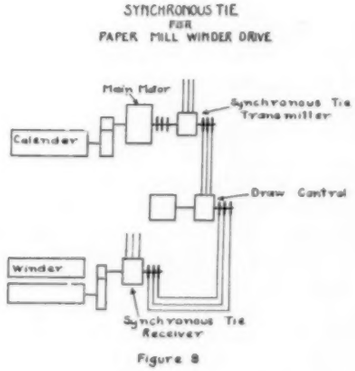


Figure 9

Another way of driving such a screwdown or similar mechanism would be to use a direct current motor as the prime mover. This motor would drive one half of the mechanism by direct mechanical connection and the other half through a synchronous tie. For many applications this is the preferred scheme.

A paper mill winder drive is an example of an application where load and speed conditions are prac-

tically steady. Figure 9 is a schematic diagram of the main features of a winder drive. The draw control consists of a wound rotor motor with a 1/1 ratio between primary and secondary voltages. By rotating this machine, by means of a suitable motor and gearing, the receiver of the synchronous tie can be made to run faster or slower than the transmitter. In normal winder operation the speed of the receiver is only one or two per cent faster than the transmitter, or just enough to keep the paper under tension and compensate for variations in roll diameter and other variables. However, with suitable equipment, the speed relations between the transmitter and receiver can be varied over a considerable range.

It is hoped that the examples which have been cited will show the wide range of applications for which the synchronous tie has many advantages and indicate new applications in the steel industry.

Discussion

DISCUSSION PRESENTED BY

J. W. Bates, Electrical Engineer, American Sheet & Tin Plate Company, Pittsburgh, Pa.
R. H. Wright, Steel Mill Engineer, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.
O. G. Rutemiller, Engineer, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.
N. C. Goin, Engineer, Westinghouse Electric & Mfg. Company, Pittsburgh, Pa.
C. O. Franklin, Asst. to Electrical Supt., Carnegie Steel Company, Munhall, Pa.
R. H. Ellis, Electrical Engineer, United Engineering & Foundry Company, Pittsburgh, Pa.
D. W. Dean, Control Engineer, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.
W. Anderson, Engineer, General Electric Company, Pittsburgh, Pa.
P. W. Miller, Asst. Electrical Supt., Carnegie Steel Company, Clairton, Pa.
F. E. Fairman, Engineer, General Electric Company, Pittsburgh, Pa.
A. C. Dyer, Engineer, Electric Controller & Mfg. Company, Pittsburgh, Pa.
F. P. May, Asst. Electrical Supt., Carnegie Steel Company, Mingo Junction, Ohio.
G. W. First, Engineer, Clark Controller Company, Pittsburgh, Pa.
L. E. Markle, Engineer, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.
K. N. Reardon, Engineer, West Penn Power Company, Pittsburgh, Pa.

J. W. Bates: On such applications as you mentioned in connection with the diagram on the bridge lift, or on this last diagram where there was a similar operation, have there been any applications of speed variation where it is possible by the use of variable D.C. to drive with a form of selsyn or some means such as you mentioned to get speed regulation between the two drives?

R. H. Wright: The winder drive is the only application involving variation of speed relations between machines of considerable power which has come to our attention. In this case the adjustment in speed ratio is quite small. This is because the takeup reel is driven by friction in such a way that the driving motor speed does not have to vary as the diameter of the roll of paper increases. Speed variation of the reel is therefore only for the purpose of maintaining a definite tension between the calendar and the winder and a small difference in speed is sufficient for this purpose. By increasing the capacity of the draw control or phase advancer it is possible to vary the speed relations over a considerable range.

O. G. Rutemiller: I might mention another application of the synchronous tie which requires extreme accuracy. In the transmission of data between the fire control instruments and the guns on an anti-aircraft 3" gun battery telephones were previously used. The external noise while such a battery is in action makes it difficult to obtain accurate results by telephone and there are a number of places where personnel errors are bound to creep in. Also speed is very important when operating on targets traveling at speeds up to 200 miles per hour and better. For these reasons the synchronous tie is being used very successfully on all of the most modern anti-aircraft guns and searchlights. These instruments are used for transmitting data between the guns and the fire control instruments. In this case two transmitters and two receivers are used. The two instruments are geared together at both the transmitting and receiving ends in such a manner that the fine indicator makes 1 revolution for each 1/64 revolution of the coarse indicator. This system is accurate to about 1 mil. (6400 mils are equal to 360°. A mil is a measure of angle used in military mathematics.)

This system has been developed still further by interposing the Bethlehem torque amplifier between the receiving motors and the gun traversing mechanism. In this case the guns are automatically trained being controlled directly from the fire control instruments.

The synchronous tie should not be confused with the various "follow-up" systems which give somewhat the same results. With a synchronous tie the receiver follows the transmitter instantaneously and does not get far out of step in making a long travel. In a follow-up system a motor at the receiving end is started and operates to make a compensating movement to the new position which is dictated by the transmitter. In this case if the speed of the receiver motor is less than the speed at which the transmitter is moved there will be a considerable lag in the receiver.

N. C. Goin: How much lag, using 4 poles, from

one direction to the other? Do you have to take it up before you pick up the receiver?

R. H. Wright: In normal operation the actual displacement between transmitter and receiver is small; probably 20 or 30 electrical degrees. The mechanical displacement depends on the number of poles in the motor. In a 4 pole motor 20 electrical degrees is equivalent to 10° mechanical displacement of the shaft, with an 8 pole motor, 5° and so on.

The accuracy of final setting on a limit switch depends on the friction. With negligible friction the receiver will come to rest exactly in phase with the transmitter after each movement. The screwdown limit switch shown in Figure 6 has very little friction. By attaching a pointer to the arm of one of these switches it has been found that the variation in setting is only a few ten thousandths of an inch out of 8".

C. O. Franklin: We investigated the possibility of using a synchronous tie to maintain the same speed on two 90 H.P. motors driving the two sections of a chain transfer in one of our beam mills, and thus prevent bending of the beams. Instead of using the synchronous tie, however, we made a very satisfactory and less expensive arrangement by tying the two motors together with a shaft and using a duplex controller.

J. W. Bates: Did they satisfy you it could be done?

C. O. Franklin: Yes, I believe it would have worked out very satisfactorily and I would like to ask Mr. Wright what size motors are used on these limit switches?

R. H. Wright: The size of the motor for any application depends upon the normal load torque, the inertia of the motor and load, the rates of acceleration and deceleration and to some extent on the frequency of the excitation circuit. In general the operation on 60 cycles is better than with 25 cycles, for the same size motors. The automatic screwdown limit switches illustrated have 3 HP. motors with pullout torques as straight induction motors equivalent to 10 or 12 HP.

C. O. Franklin: Do you use a large gear reduction between the motor and the limit switch?

R. H. Wright: The gear ratio for a limit switch application depends entirely on the number of revolutions of the transmitter per inch of roll lift and the movement of the limit switch per inch of roll lift. For example, in one of the illustrations the transmitter is connected directly to the screwdown motor, which makes 50 revolutions per inch of roll lift. The screwdown limit switch makes 1 revolution per inch of roll lift. Therefore the gear ratio between the receiver motor and the limit switch is 50 to 1. The transmitter and receiver motors are wound for 4 poles, 60 cycles and therefore have a synchronous speed of 1800 RPM. In operation, the maximum speed of these motors is less than 1000 RPM. In another similar installation 25 cycle, 4 pole, 750 RPM motors were used with gear ratios such that the operating speed does not exceed 450 RPM.

R. H. Ellis: What rate of acceleration may be obtained with the synchronous tie?

R. H. Wright: Uniform acceleration is not a problem in either direction of rotation. However, in one direction of rotation, the system may be unstable if the acceleration is not smooth and there is a reversal of torque without reversal of rotation.

The maximum permissible rate of acceleration can be calculated, just as for any other form of motor drive. The speed-torque characteristics of the synchronous tie can be determined by test or calculated if the induction motor characteristics are known. Knowing the flywheel effect of the load and of the synchronous tie, the maximum permissible rate of acceleration can be determined.

R. H. Ellis: Suppose you had one machine rotating all the time with the second machine at standstill and then close the circuit in the secondary, would the second machine pick up speed?

R. H. Wright: Connecting the transmitter and receiver while the transmitter was in motion would cause the receiver to run away. Even when both machines are at rest it is usually necessary to take special precautions in connecting the machines together to prevent runaway of the receiver. Runaway is avoided by first applying single phase excitation and then three phase, after the machines are locked in synchronism.

D. W. Dean: You stated drives would become unstable unless you got enough torque. Is the synchronous tie inherently unstable?

R. H. Wright: The synchronous tie has the same inherent stability as an induction motor. However, the characteristics at pullout are different. If the pullout torque of a straight induction motor is exceeded, the motor will slow down or stop unless the torque is reduced. If the pullout torque of a synchronous tie is exceeded, the motors fall out of synchronism. Each machine then tends to run independently as an induction motor. Usually the transmitter is held back by the prime mover to which it is connected and only the receiver comes up to speed. The synchronous tie is perfectly stable within its torque limits, but acts differently from a straight induction motor when the pull-out torque is exceeded.

R. H. Ellis: Suppose you have one of these synchronous motors on a screwdown with a 50 to 1 gear ratio, can you expect to operate the indicator in the pulpit perfectly?

R. H. Wright: Yes. The effect of gear back lash and multiplication factor will be present just as in the case of a mechanical connection. A mill screwdown may be arranged so that the screwdown motor makes 50 revolutions for one inch of roll travel. With a direct connected transmitter, the transmitter and receiver also make 50 revolutions. The automatic screwdown limit switch makes one revolution for one inch of roll travel. Nevertheless roll settings are very accurate.

W. Anderson: We have in operation just such an indicator, which we applied to a Blooming Mill. On this application there are two indicators, one for the fine, the other for the coarse indication. The coarse indicator is something less than 360 degrees for full opening of the Blooming Mill. The second fine, or vernier indicator, is so geared as to measure thousandths of an inch. The two selsyn transmitters are geared to the Blooming Mill mechanism and the indicators are located in the pulpit. The operation is quite satisfactory and the mill operator is very much pleased with it.

We have another interesting application of the

selsyn on a sheet mill where the device is used for measuring the length of the sheet. The transmitter is belted to the shaft of the steam engine. The receiving motor drives a large pointer over a dial about 18" in diameter with a clear glass except for a ground glass ring about 2" across. The sheet while being rolled passes over a flag switch and depressing the flag switch closes the circuit between the transmitter and receiver. This causes rotation of the receiver until the flag switch is released and thus gives indication of the sheet length. The receiving selsyn motor is dampened so as to have no overshoot although the pointer drops back instantly to zero after the flag switch is released.

This installation was put in as an experiment because we did not know whether its accuracy would be what was desired. We find that it is quite possible for an operator to catch the maximum deflection of the needle. A change in roll diameter or the length of sheet desired is corrected by a new mark on the ground glass ring in the first few passes and without any great difficulty. The satisfaction of the customer has exceeded our expectations. The roller finds the device of considerable assistance to him in rolling sheet.

I might add some further comments about the vertical lift bridge mentioned in the speaker's most interesting paper. I was fortunate in having the pleasure of selling the equipment for this lift bridge, which is a very interesting application of power selsyns. The operation has been absolutely satisfactory. This bridge not only has a synchronous power tie but in addition has skew limits and, should these fail, has further manual means for controlling the bridge. In several months' operation there has been, so far as I know, no reason to call on the emergency features. Operation of the bridge has been successfully accomplished with one main motor disconnected.

R. H. Wright: I am glad to hear that confirmed.

N. C. Goin: Why don't they make the main motor big enough to do the job and do the work with the synchronous tie?

W. Anderson: It may be a case where the reliability demanded of the device is such that they wish to make certain that failure of the synchronous tie would not hold up operation. If we depended on only one method of levelling, the bridge might be made inoperative without auxiliary devices. It must be remembered also that this operation with power fed across to the other side of the synchronous tie is only under emergency and regular operation of the bridge by this method would require larger units.

P. W. Miller: What is the relative accuracy between 25 and 60-cycles all other things being equal?

R. H. Wright: There would not be any difference in the accuracy. The only factor affecting the accuracy would be the number of poles in the motors. A displacement of a given number of electrical degrees would mean less mechanical displacement as the number of poles increased. Voltage and frequency conditions are usually steadier in 60 cycle power systems because most 25 cycle steel mill power systems have some gas engines in the system. Variable voltage and frequency are a handicap.

F. E. Fairman: The thought comes to me in connection with this discussion of synchronous tie units that it might not be inappropriate to mention another kindred application which, while it involves selsyn units, does not utilize the principle of power transmission between the transmitter and the receiver unit in the usual manner.

The application to which I refer is the general class of which the selsyn thyratron automatic screwdown equipment may be regarded as a type. In this case the transmitting selsyn unit or units (single unit or a double unit coarse-fine arrangement) are set to a desired position. Then, upon the proper contacts being set up in connection with the ordinary magnetic control, the main motors are driven in one direction or the other until a small selsyn unit (usually a double unit coarse-fine arrangement) which is geared to the main motor or one of the drive shafts, indicates that the drive has come to the proper position set on the transmitter unit. This method of control involves thyratron tubes in addition to the selsyn units. The thyratron tubes in this circuit function in a discriminating manner as determined by the difference in the phase angle of the voltage of the selsyn secondaries, which phase angle is the same for both units only when they are in the same angular position.

While, as previously mentioned, this is not primarily a power transmission application, yet it will doubtless prove extremely useful in many accurate position setting applications such as those involved in the precise locating of traveling gauge heads, shear limit switches, etc.

F. P. May: We have a small application of the selsyn control blast furnace signal system to turboblower. I would like to ask Mr. Wright if there has been apparatus developed that you can attach to a standard gear set that operates a hot metal haulage system thereby indicating the exact position of the ladle car to the operator.

R. H. Wright: That would involve a special indicator. Standard indicators are available for a wide variety of purposes, but probably not for that particular job.

W. Anderson: It is surprising how long these devices have been available but only quite recently has there been any great interest shown in their possibilities. I should say that you could accomplish what you want, so long as there is not any possibility of a change in the relationship of the different moving parts, such as a stretching cable, track slippage, etc. The control board built years ago for the Panama Canal had all sorts of modifications of the simple indicator. In this case a miniature model of the canal locks is used, on which the chains in the locks rise and fall, the gates swing open and closed, and the water level indicators rise and fall, in perfect miniature of the equipment itself.

I assume in this case very great accuracy is not required and I feel sure the accuracy to be secured from the selsyn indicator would be sufficient. Unless there is stretching of the cable or some similar difficulty as mentioned above, you ought to have no trouble in getting accurate indication. The less the load on a selsyn system the more accurate it becomes and any difficulty with accuracy on this count can usually be easily solved by using large enough selsyns.

R. H. Wright: Where you do not have a cog railroad there will be some slippage. Over a long

period the slippage might be self compensating as the slip would be first in one direction and then in the other.

F. P. May: Several feet would not make any difference.

R. H. Wright: While such equipment is probably not listed in any catalogue, there is no reason why it cannot be done. The equipment would be somewhat special.

A. C. Dyer: We have never used that system on screwdowns, but we have used it on other applications.

There is a question that occurs to me. I wonder if Mr. Wright could tell us the difference in torque between single and three-phase on two motors of the same size?

R. H. Wright: I have only one recollection on that point. In a test on a 3 phase machine we obtained somewhat less torque with single phase excitation than with 3 phase excitation. As shown by one of the curves, the running torque of 3 phase machines is less than the standstill torque in one direction of rotation. In the same way the running torque with single phase excitation is less in either direction. Since the torque at standstill is less with single phase excitation and falls off with increasing speed, the 3 phase arrangement is preferable. Also, the vibration of large machines with single phase excitation is objectionable.

A. C. Dyer: I had in mind a three-phase transmitter in driving the limit switch. Would it not be a large size motor for a man to operate manually?

R. H. Wright: An automatic screwdown limit switch has to make a certain number of revolutions for each inch of roll movement. The connection between the limit switch and the screwdown mechanism can be either electrical or mechanical. Both types of connection are in successful operation. Except for making vernier adjustments, the operator has no control over the movement of the limit switch, as it moves whenever the screwdown moves.

D. W. Dean: On this calender drive you spoke about the speed relation. The two speeds are always in synchronism. My original idea was that the draw control was the means of shifting the phase relations and thereby changing the tension of the paper which did not change the speed relation. Assuming you have speed on calender operating at 100 per cent, is it possible to change the synchronous drive to 99 per cent or 101 per cent?

R. H. Wright: That is what is done. In a paper winder, the motor, or receiver, does not drive the winding roll directly but drives a friction roller which has a surface speed approximately equal to the speed of the paper. This friction roller drives the winding roll by friction, so that the speed does not have to be varied with the diameter of the winding roll. Therefore, the relative speed of the motor has to be varied only a small percentage to keep the paper taut.

D. W. Dean: Is draw control a frequency changer or phase changer and how does it function during starting?

R. H. Wright: In starting the paper through a calender and winder the draw control, really a frequency changer, is driven by an induction motor. A fixed frequency is applied to the primary of the draw control and its rotor rotated at such a speed that the slack in the paper is quickly taken up. When the slack is taken up it then becomes a matter of keeping the paper under tension.

G. W. First: Is that ½ of 1% variation necessary to take care of variation in the diameter of the winding reel connected to the draw control?

R. H. Wright: As explained before, the speed of the winder motor does not have to vary with increasing diameter of the roll of paper, since the winder roll drives the roll of paper by friction. The draw control merely compensates for the elongation of the paper in the calender.

L. E. Markle: A very good example for applications of synchronous tie-in systems is found in paper making machines of some 10 or 12 years past. In this system a master or reference synchronous machine was made to generate a certain fixed or given frequency. The various sections—usually 6 to 10 in number—of the paper machine, were each driven by a D.C. motor upon which there was sufficient speed regulation to control the motors and hold them in correct speed relation with each other. From each of the sections of the paper machine an individual frequency generator was driven and its speed, consequently its frequency, was matched against that of the master or reference frequency generator.

For each section of the paper machine there was also an individual speed regulating synchronous tie unit which was subjected to the frequency generated by the master set and also was subjected to frequency generated by the individual section machine generating unit. So long as the frequency imposed upon the regulating unit from the master machine was the same as that imposed upon the differential regulating unit as received from the individual frequency generating unit, the differential unit exerted no torque to run in either direction but remained absolutely stationary. If there was a slight discrepancy in the frequency of the master set, and the individual set as imposed upon the regulating set, the regulating set was inclined to creep one direction or the other depending upon whether or not the frequency from the individual set was high or low. This creeping torque was transmitted through a system of relays or contacts which in turn actuated motor driven speed regulating rheostats in the field of the main D.C. motors which drove the paper machine.

With this system the entire paper machine was satisfactorily locked together by the synchronous tie-in system and the paper stock in liquid form was transformed into a roll of dry paper by a continuous process without any mechanical connection between the various sections of the paper machine.

For such an application, the master or reference generator, the individual frequency generator, the differential regulating units were all standard wound rotor motors without any special characteristics whatsoever.

K. N. Reardon: The West Penn Power Company does not have in service any Selsyn or equivalent type motors of the high power type as have been discussed during this meeting. We do, however, have a number of interesting installations in which instrument type Selsyn motors are used. One of these installations is similar to the draw control which has been mentioned in connection with the paper mill. This instrument type draw control is used with the frequency and load regulating equip-

ment at one of our power houses. In our regulation we obtain accurate record of any deviation from accurate time by mechanically comparing the time of a Telechron clock with that of a very accurate pendulum clock enclosed within a glass case. From the detection of errors by means of this equipment proper impulses are sent to the synchronizing motors of the main generators so that load and frequency may be increased or decreased according to need. It is occasionally necessary to cause the system to gain or lose time in accordance with the detected error. Accordingly by means of a small frequency converter we are able to change frequency of the supply to the Telechron clock by as little as one-hundredth of a cycle. With this slight frequency bias an error is purposely introduced into the error detecting equipment and the system time is adjusted so that the Telechron clocks scattered throughout the West Penn System are again reading accurate time. It may be noted that seldom are these clocks in error more than one or two seconds.

In this same power plant Selsyn motors are used to record on a 20" dial in the boiler room the total load of the plant. This is done by means of a Selsyn transmitter connected to a graphic totalizing wattmeter and the movement of the wattmeter pen horizontally on the chart is converted to a rotary movement of the hands on the large dial in the boiler room. In other installations the Selsyn motor connected to the vertical movement of the governor rack on the 30,000 KVA generators transmits to a receiver in front of the load dispatcher an indication of the load on the generator in terms of steam valve opening. Still another application is made by connecting a Selsyn transmitter to a Leeds and Northrup frequency recorder whereby the slight horizontal pen movements are transmitted and received by a Selsyn receiver at the load dispatcher's desk. Here again a graphic record is converted into an indicating record on a 7" dial movement.

Industrial Lighting Progress

By P. R. HOLMES
Illuminating Engineer, General Electric Co., Philadelphia, Pa.

Presented before the Philadelphia District Section of the A. I. & S. E. E., December, 1932.

Recent years have shown considerable progress in the art of lighting. Notable improvements have been made in artificial illuminants and auxiliary equipments. General acceptance, however, has been slow, particularly in the reflecting equipments, as evidenced by the fact that 75% of industry today is challenged on the score of adequate and proper lighting. A very recent report from the Department of Labor states that accidents in United States industries attributable to faulty lighting, cost the service of 125,000 workers valued at $150,000,000 annually. Certainly this alone should be conclusive enough proof that there is still much to be accomplished.

In attempting to analyze the causes for the majority of plant accidents resulting from faulty illumination, responsibility is generally placed on either inadequate or improper lighting. Inadequate light needs little explanation. While we are liable to find it in any part of the shop, the most common locations are in aisles, passageways and non-manufacturing areas. One seldom stumbles over objects that can be readily seen. Under good illumination, our eyes function and transmit the message to our minds so quickly that we avoid obstacles almost automatically. Under inferior lighting, the difficulty of avoiding obstacles becomes great. In any plant, a careful inspection periodically will reveal the hazards existing.

Improper lighting covers a much broader field. When considering faulty illumination, it is a very common habit to think only of the artificial lighting system. A recent survey conducted for one of our large companies indicated that in their case daytime conditions were far more troublesome than night. On account of the arrangement of work, many employees were forced to face windows through which considerable sky area was visible. The contrast created between this bright sky area and the lower brightnesses of the work and interior surroundings were such as to not only cause eye fatigue attributable to the glare, but if continued would be certain to cause impairment of vision to the workers. This condition which illustrates our definition of glare, namely light out of place, is not uncommon in many of our working areas today and it is to be hoped will receive much greater attention in the future.

Cause for other glare conditions may be accounted for by the fact that when incandescent lamps were improved by replacing the carbon filiment, there was an increase in the intensity and intrinsic brilliancy. With the introduction of the gas-filled lamp and steady improvements since, there have been further increases in the brightness of the light source. Reflecting equipment developments rapidly followed the improvements in lamps, but the fact that changes in lamps were made without the corresponding equipment changes have, in many cases, brought about conditions less satisfactory than in the past.

Furthermore, the lighting units were in the past located promiscuously about the room without consideration for uniformity in the distribution of light. Whenever it was thought that more light was necessary, the electrician was called in. A drop cord was installed, from which a bare lamp was hung. If the light was too bright for the worker's eyes, he often made a makeshift shade protecting his own vision but leaving unshielded portions of the lamp to become a source of annoyance to his neighboring workers.

The ill effects of glaring light sources in the line

of vision are hardly less important than the glare from sources out of the direct range of vision which is reflected back from the brightly polished surfaces of the work and surrounding objects.

With a well designed system of outlets to provide general lighting, it is only necessary to select the lamp size and equipment to furnish the proper quality and quantity of illumination.

Steel mill operations are so diversified that space does not permit nor does it seem practical to present them here in a complete itemized list, with the the footcandle levels required in each case. Illumination levels have, therefore, been suggested for a number of typical operations and departments from which the lighting requirements of others may be gauged.

2 to 4 Foot Candles

Rough Stock Rooms, Rough Packing, Cleaning, Rough Clay and Chemical processes, Coal and Ash Hauling, Aisles, Passageways, Stairways, etc., Locker and Wash Rooms, etc.

6 to 8 Foot Candles

Soaking Pits, Reheating Furnaces, Rough Wood Work, Steel Fabrication, Steel Casting and Heavy Rolling, Plating, Grinding or Rolling Mills, Rough Bench and Machine Work, Rough Assembly, Rough Molding and Core Making, Engine, Transformer and Switchboard Rooms, Rough Inspection, Shipping and Receiving.

10 to 20 Foot Candles

Fine Wood Working, Fine Stock Rooms, Automatic Steel Manufacturing Machines, Sheet Metal Works, Polishing, Burnishing, Painting, Fine Packing, Fine Bench and Machine Work, Automatic Machines, Light, Medium Inspecting, Fine Molding and Core Making, Fine Forging and Welding, Fine Assembly, Offices.

20 to 50 Foot Candles

Fine Inspecting and Sorting, Extra Fine Paint Finishes, Extra Fine Bench-Machine Work, Extra Fine Assembly, Drafting Room.

The selection of the type of unit to be used necessitates a consideration of the location in which it is to be installed. In this connection, it should be noted that for purposes of illumination design, steel mill structures may be divided into two general classes. First, there are those buildings in which the mounting height of lighting equipment is limited to 30 feet or less. Second, there is a large number of buildings in which the presence of traveling cranes and other factors make necessary the locating of lighting equipment at extreme heights. It is to be expected then that the treatment required in the planning of lighting is different for the two cases.

Fortunately, those buildings coming under the first classification usually house departments and operations which are typical of most manufacturing establishments. For this reason, and because of the fact that lighting equipment for these ordinary industrial purposes has become so well standardized, it is only necessary when dealing with these buildings to select from a few types the particular one and size best adapted to the problem at hand. Porcelain enameled steel reflectors such as the RLM Standard Dome and the Glassteel Diffuser, and Dust-Proof units fulfill practically all the requirements of those buildings with the lower ceiling heights. When properly installed and equipped with lamps of a sufficient size to give the required intensity they make up a lighting system which embodies a degree of efficiency, freedom from glare and shadows, control, flexibility, ease of maintenance and other desirable features hitherto unknown in industry.

The high buildings of the second classification, on the other hand, require a more specialized treatment and probably the most important single factor in this connection is the selection of the lighting unit. The presence of traveling cranes in these buildings usually necessitates the placing of the equipment near the roof or, at least, the truss chords, and since these structures are usually of great height in comparison with their width, the use of reflectors which direct a great proportion of their light in the higher angles must result in a relatively low overall efficiency of the system. This condition is further aggravated in the steel industry by the fact that the walls of the buildings are almost invariably so dark as to eliminate any possibility of light being reflected by them. It is evident, therefore, that the requirements here would be best met by a unit which directs and confines the light of the lamp within small angles as measured from the vertical axis of the unit. In this way the light is delivered to the working plane with the least possible intervening losses.

Equipments which embody these characteristics in their design are available in metal and prismatic and mirrored glass types. It must be appreciated, however, that the greater degree of light control required and a limited application make them necessarily more expensive than the standard forms of porcelain enameled reflectors. On the other hand, the available maximum lamp sizes usually limit spacing distances to about 40 feet so that the first cost of systems using this type of equipment is usually slightly higher than if the RLM or similar standard units were used. Good engineering, therefore, demands that in any particular case, this increment of cost be justified by higher efficiency or other accruing advantages.

Within the last year we have seen developed a new combination in lighting employing mazda lamps and mercury vapor tubes. As is generally pretty well recognized, the quality of light delivered from an incandescent lamp favors the red and yellow end of the spectrum, while with the mercury vapor it is exceptionally strong in blue-green. A proper mixture of these two sources will produce a light very near to actual daylight. This type of equipment offers a very satisfactory solution to the problem presented by those operations where daylight quality is imperative. Heretofore, corrective color quality methods employed a filtering out of the excess red and yellow rays of the incandescent lamp by means of bluish green glass with losses in total light delivered by the source of from 30 to 90 per cent depending on the resultant effect desired. With the combination equipment, two sources of nearly equal efficiencies are employed in an additive rather than subtractive process.

The Simonds Saw Co. of Fitchburg, Mass., in

their new windowless factory were the first to employ this type of lighting on a large scale.

The lighting equipment used consists of a 50" mercury vapor tube in the shape of a U with four 75-watt mazda lamps in a row down the center. The combination takes a total lead of approximately 650 watts. These units are spaced according to truss construction on 14 feet x 20 feet centers and mounted 16½ feet above the floor. An average illumination level in service of the order of 20 to 25 f. c. is anticipated. Unfortunately business conditions during the past year have prevented an actual check.

One-half of the mercury vapor tubes are made of ultraviolet transmitting glass which makes this installation unusual in that in providing adequate light for seeing, advantage has also been taken of the possibilities to furnish the worker with some of that portion of the invisible spectrum which is accepted as vitally necessary in the maintenance of health.

In discussing this new phase of artificial lighting with the extended purpose of health maintenance, as well as for seeing, curative values may be eliminated. Illness and disease should be exclusively the field of the medical profession. In curative value radiation, artificial sources have not only successfully challenged the sun, but have achieved results far beyond those obtainable with sunlight. This is due to the fact that certain artificial sources supply radiant energy not found in sunlight. In this new lighting development particular care has been taken by the manufacturers to provide equipments that simulate sunlight, thereby giving adequate and proper light for seeing and in addition supplying health benefits to those who work and play in the indoor world.

Particularly in congested cities, valuable ground and floor areas are being wasted to admit inadequate and uncertain daylight indoors. Wall space is being consumed by windows. Architecture is being handicapped by the window and skylight habit. Setbacks of upper stories are demanded by ordinances. These losses combined with heat losses, investment and maintenance charges are mute evidences that the development of artificial light and lighting has overtaken and passed most persons because of retarding habits acquired before the age of modern controllable and relatively inexpensive artificial light. Daylight equipment to let light in and to let vision out should be installed where it can be useful at reasonable cost. But artificial light is always necessary as insurance against failure of daylight.

This fact combined with a realization that our present-day window glasses do not transmit the health-maintaining radiant energy of sunlight appears certain to strike an appealing note to the plant and building managements which will give the necessary impetus to a continued development and application of artificial sunlight equipments.

While the comments so far have been directed toward the problem of supplying adequate general lighting, it should be realized that where unusual visual tasks are encountered, it is necessary to design special equipments for those specific applications. Experience with such applications has demonstrated that artificial lighting can readily be controlled in quantity, quality and color and that it not only becomes more practical than daylight, but also accomplishes results unobtainable from natural lighting. Particularly is this true where a directional beam, or a series of them, is required, or where a constant level of a given spectral quality of illumination must be maintained.

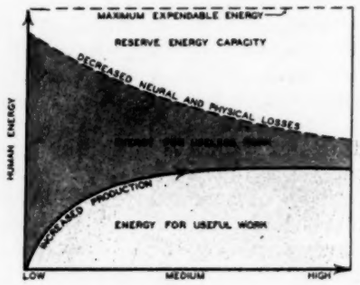


FIG. 1.—A diagrammatic view of the expenditure of energy by a human being as a seeing - machine engaged in a visual task.

In recent years those who have been following the science of seeing have become convinced that in applying the visual sense, the human machine expends energy other than that required in the process of seeing. An analogy might be made in the case of a pedestrian crossing a street. A certain amount of energy is required to transfer the weight from one side to the other, which may be likened to the useful effort required in seeing. There is an additional energy required in determining whether the crossing may be made in safety, which may be likened to unmeasurable amount of nervous energy expended in useless work and, in addition, nature has provided us with a reserve energy capacity to put forth extra speed should a vehicle be approaching which is not unlike the ability of the eye to meet exceptional requirements, but which if maintained for any length of time is certain to result in severe eye-strain.

These reactions are diagrammatically shown by Figure 1. No numerical values are given because they are not known and because at the present time it is impossible to give definite relations between the upper and lower values.

The lower curve involving external factors may be regarded as a composite one representing the results of numerous researches for the purpose of determining the relation between illumination and production. Sufficient information is available on this subject so that the results are accepted without question.

The upper curve, representing external factors, such as nervous muscular tension, has up until the present time been imaginary. A very extensive test completed within the last three months gives us for the first time comprehensive data as a basis for the true character of this curve.

In this test—fourteen subjects—eight men and six women of normal or nearly normal vision were employed. 308—thirty-minute tests on different days were conducted under illumination levels of 1, 10 and 100 f. c.

Reading was taken as the visual task for this test. The subject was seated at a table containing an inclined rack for holding the book. He was instructed to read naturally and steadily. Hence the test was conducted under normal, rather than forced conditions which greatly facilitates the interpretation of the results and enhances their value. The subject was further instructed to rest two or three fingers of the left hand upon a large flat knob of a concealed key and to press the key firmly as he read the last

word on each page. This and various other expedients were employed to conceal from the subject the true purpose of the test.

The pressure that was unconsciously exerted on the key during the reading under the various illumination levels was automatically recorded at five-second intervals. The final results as indicated by the curve in Figure 1 are the average values obtained from the complete set of tests. Physically the pressures exerted were 63.2, 54.1 and 43.0 grams under the 1, 10 and 100-f.c. intensities respectively.

It is apparent that these differences in reactions resulting from reading under different illumination levels are of such definiteness and magnitude that they are capable of creating muscular strains on the hand which are measurable. Human energy expended in nervous muscular tension, in this case, is wasted since it accomplishes nothing useful. This waste of human energy due to inadequate levels of illumination apparently indicates nothing else than an effect of greater ease in a human seeing machine when engaged in a relatively easy task under intensities of illumination greatly above mere visual requirements.

With a knowledge of the information available today there should be no discouragement in the progress of the past. Steady improvement in lighting practices may be noted in the Lighting Codes for Factories, Mills, and other work places published in the Technical Press. We have passed from a period of mere light to a period of mere footcandles and are now in a period where productive footcandles are being considered. In the future, it seems reasonable to believe we shall see a humanitarian footcandle period where illumination levels not only of sufficient quantity to obtain the most productive effort from the worker, but also an additional amount to reduce the neural and physical energy expended.

Slow Blowing-Blast Furnaces*

By W. A. HAVEN
Cleveland, Ohio.

Some of the most interesting developments in pig iron manufacture during the last year are to be found in operating practices that were originally considered purely emergency measures, but that are now being hailed as permanent improvements. The most important of these has been "slow blowing."

To the experienced blast-furnace operator the advantages to be derived from a careful adjustment of the blast volume to the size and design of the furnace, and particularly to the quality of the raw materials, have always been realized. The trend to large 1,000-ton furnaces, as the author pointed out in an article published in 1926, could scarcely have been justified on the basis of increased productivity alone. Recently, the pressure from the plant management has been to get as little tonnage as possible, while keeping the furnace in operation, not only for making the requisite amount of hot molten metal, but as a producer of gas for the manufacture of coke and coke-oven gas, the generation of power, and the heating of metallurgical furnaces.

This situation has resulted in "slow blowing," or blowing the furnace at a rate somewhere below the point of maximum production. Blast volumes were gradually reduced to keep pace with the operation of other departments. Many had anticipated serious operating difficulties from the building-up of the hearth, bosh, and stack, with resultant hanging and checking, but these were not encountered. On the other hand, surprisingly good results followed. Flue-dust losses were substantially reduced, the coke consumption was decreased, and the quality of the iron became more regular and better.

With the demand for tonnage declining over a period of almost three years, it naturally followed that the advantages derived from slow blowing should be pressed to the utmost, and today there are many instances of stacks being driven at only about one-half of what was considered their normal rate. The figures of Table I are typical.

TABLE I

	Normal Operation.	Slow Blowing.
Wind. Cu. ft. per min	48,000	25,000
Output. Tons per day	762	372
Coke. Lb. per ton of pig	1,638	1,707
Amount of scrap used. Per cent	12.6	None
Flue dust produced. Lb. per ton of pig	353	111
Metallic loss. Per cent	6.50	0.33
Off-sulphur iron. Per cent	0.36	None

An examination of these figures discloses the tremendous reduction of losses that can be accomplished if gas velocities through the furnace are kept at a minimum. At another furnace in the same plant, the flue-dust losses were reduced 80 per cent., and at many other plants throughout the country less than 100 lb. of dust are being made per ton of pig, which can be economically returned to the furnaces without sintering.

The thermal efficiency of the operations shown in Table I likewise speaks well for slow blowing, if due consideration is given to the amounts of scrap consumed. Given an equal amount of scrap in the burden, the advantage in slow blowing would have been not less than 200 lb. of coke per ton of pig iron.

The adverse results of slow blowing are of course higher labor costs and higher fixed charges, which are directly proportional to the tonnage. But even at a 50 per cent rate, the net effect in many cases has been a final cost of pig iron which is as low as, or even less than, that obtained by the so-called normal operations.

Associated with slow blowing, as a means of keeping the blast-furnace production in step with the hot-metal requirements, is intermittent operation. Here, the results, while not so productive of econo-

*Abstract of paper to be presented before the British Iron and Steel Institute, May, 1933.

mies as slow blowing, have furnished some surprising upsets to former accepted theories.

Short periods of banking, especially over the week-end, had been tried many times in the past, but with such unsatisfactory results as to discourage any regular procedure of this nature. Now, however, instead of a complete shutdown of the furnace, a slight blowing is kept up—for which a new word, "fanning," has been coined. In the past, fanning a furnace was something that operators were prone to avoid, most of them preferring a complete shut-down, for the same reasons that have been listed against slow blowing.

Now, however, the beneficial effects of fanning, as compared with complete stoppage, are becoming apparent. Fanning keeps the hearth hot, probably has a tendency to keep the furnace walls clean, eliminates the necessity of purging the mains, and accomplishes a considerable amount of "predigestion" of the stock which greatly facilitates easy resumption of blowing. In this way the necessity of coke blanks is avoided, and operations are carried on with a rather amazing thermal efficiency.

Almost any combination of blowing and fanning periods can be worked out, either to meet the tonnage requirements or to accommodate periodic demands for hot metal. In almost every case, however, it would seem, on the basis of theory, that the best results would be obtained when the period of blowing is not longer than that required to empty the furnace of stock "predigested" by fanning; and in practice this procedure is generally followed. From 4 to 12 hr. blowing, alternating with periods of fanning of from 4 to 20 hr. duration, covers most of the cases with which the author is familiar.

In general, the lesser advantages from intermittent operation lead to the use of continuous slow blowing where the conditions are such as to make the method of reducing the production optional, and this is in spite of the fact that during the fanning period a complete laying off of the operating force with the exception perhaps of one foreman or water tender, is generally followed. As with slow blowing, however, it may be stated with assurance that intermittent operation has been so successfully worked out in practice that it may be considered a permanent contribution to the art and one that will at times be utilized to advantage after the depression is behind us.

Discussion

Non-Metallic Bearings *

▲

Discussion Presented By

N. C. Bye, Chief Engineer, Henry Disston & Sons, Inc., Philadelphia, Pa.
L. F. Coffin, Superintendent Mechanical Department, Bethlehem Steel Company, Sparrows Point, Md.
W. H. Burr, Electrical & Mechanical Supt., Lukens Steel Company, Coatesville, Pa.
F. W. Vogt, Engineer, Joseph T. Ryerson & Son, Inc., Jersey City, N. J.
C. M. Thompson, Electrical Engineer, Henry Disston & Sons, Inc., Philadelphia, Pa.

N. C. Bye: The use of composition bearings has been somewhat recent with us. We have found the same virtues in them that Mr. Coffin did—they reduce the power required by the mill and increase the life of the bearing.

There is one other advantage we have found—on a shape mill you can run longer periods without adjusting the mill and still maintain shape, because the composition bearing doesn't change, due to the expansion by the heat. We can also shut down over noon periods, or for intervals up to two hours, and start up again without making any major correction.

We do find, however, that we have considerable difficulty from burning, and I would like to ask Mr. Coffin for further information in regard to the grooving of the bearings on the bull heads, that is the finishing passes. We only groove the flat surface of the bearing and do not groove the thrust faces, but on the edger passes, where the thrust pressures are much greater, we have tried various methods of grooving but have not found any method which will preserve the thrust faces to our satisfaction. Do you know of any method to groove these faces and have you had any experience on edger passes in particular?

L. F. Coffin: Regarding grooving of bearings, I presume Mr. Bye refers particularly to the difficulty with the wear on the thrust collar?

N. C. Bye: That's right.

L. F. Coffin: To provide for thrust we are using a separate renewable thrust collar, with an annular groove cut around it at the point of juncture with the main bearing shell, and in most cases of a depth equal to one half the thickness of the main shell. As to the particular merit of this groove, I am not sure, but it is our practice.

N. C. Bye: We take the thrust collar and instead of following the fillet of the roll neck, we make the thrust collar a straight line, so we have what corresponds to the cutaway as you have explained. In addition to that, at the bottom of the face, we make a groove down about three-quarters of the length of the face so it forms a pocket. Even then, we have trouble with burning.

L. F. Coffin: We do not now use any grooves in the main shell at all, though we have used them. We have tried them in Lignum Vitae and in nearly every case got into difficulty. Instead we use a good bevel at the edge of the shell to lead the water in. It is difficult to see why there should be any difference between the application of water to a bearing

*Paper presented by L. F. Coffin, before the Philadelphia District Section of the A. I. & S. E. E., April, 1933, and Published in the April issue of the Iron and Steel Engineer.

of this type, and of oil to a main engine bearing. Some of the engineering societies and larger electrical manufacturing companies have done considerable research work, in which it has developed that the less grooving under bearing pressures, the better.

N. C. Bye: Do you find any difference in the behavior on fast speeds over slow speeds?

L. F. Coffin: In real slow speeds and heavy loads, the bearing has a tendency to cut out on one side, whichever way the direction of the thrust is, due to the fact, probably, that the water film has not been maintained.

N. C. Bye: Do you make any change in your installation for different speed operation or are both installations exactly the same?

L. F. Coffin: They have been, so far. Now, just as a suggestion on thrust collars, it might be entirely possible to bevel the entering edge of the thrust collar and put a stream of water at that particular point so that the effect would be the same as on the main shell. The difficulty on thrust collars, in many rolling mills, is that there is not sufficient bearing surface on account of the large neck diameter required and the small roll body. But the statement I made in the paper might appear to be true, that the composition should withstand the thrust as well as or better than a brass thrust collar. That is a problem that is being worked on, and I understand there are some new composition materials in process which it is believed may have a higher compressive strength and be more homogeneous and take on a higher gloss and help that situation somewhat.

W. H. Burr: This may not be quite fair, and yet I think the principal purpose of a discussion of this kind is to benefit all who are contemplating an installation of this kind: it might be interesting to know if you have made any installations, or found any places in your application so far, where you decided that it was not desirable to go ahead with the non-metallic type bearing. In other words, it might keep some of the rest of us from getting into trouble in making applications.

L. F. Coffin: We haven't, except for a few low speed stands, at very low speeds and heavy loads, where we anticipated difficulty.

W. H. Burr: You went down to 117 feet per minute. Is that right?

L. F. Coffin: We haven't successfully proven that 117 feet per minute can be used, but we believe it can be. But we have successfully operated stands at speeds of 163 feet per minute.

W. H. Burr: That brings up another point: have you any figures on the comparative costs?

L. F. Coffin: I haven't any figures here with me. That might depend upon which manufacturer you buy from.

W. H. Burr: I believe that Mr. Vogt, of Joseph T. Ryerson & Son, Inc., is in the room. Wonder if he has anything to offer on that point.

F. W. Vogt: Well, I can't say definitely, but if consideration is given to the fact that a composition bearing will outwear from four to ten metal bearings, then the first cost of composition type bearing is less.

Taken piece by piece the composition bearings may vary from being equal in price to being several times the original cost of the brass, depending on the size of the brass which is being replaced, and the amount of machine work and labor involved in making the metal replacement.

C. M. Thompson: There is one question I would like to ask and that is on the low speed installations, whether drilling the bearing for increased water pressure has been tried out. Does drilling around the periphery of the bearing, I understand that that is done in some cases, help?

L. F. Coffin: Do you mean attempting to force water in under pressure into the center of the bearing?

C. M. Thompson: Yes.

L. F. Coffin: We haven't done any of that. It is interesting to speculate on the bearing pressures we secure in mills using these particular bearings. Pressure per square inch in the rolling mill, is a subject about which we have needed more information for years. One large manufacturer of roller bearings, reports that a formula used or developed by Ecklund in Germany in 1927, has given fairly reliable results as applied to actual pressure tests which they have made on mills of various classes, from small mills to large plate mills. Just as a matter of interest and without any desire to give it reliability, but more from a comparative point of view, we have applied this formula to certain maximum conditions in some of the mills under discussion and find bearing pressures per square inch as follows:

In a 110" Plate Mill, we have a bearing pressure of 2,460 lbs. per square inch using brass bearings. Using composition bearings in this mill under the same conditions—2,170 pounds per square inch, because when the composition bearings were applied they were given a greater arc of contact, with more bearing surface and, therefore, the pressure per square inch was less.

In a 60" Universal Plate Mill, on brass, the bearing pressures were 2,430 pounds; on Lignum Vitae 1,960. Here again, in the case of the Lignum Vitae we had almost a 180 degree bearing, consequently there was much greater bearing surface.

In the 12" Skelp Mill on one stand near the finishing end, on Lignum Vitae, we find bearing pressures of 326 pounds per square inch. While these figures should not be relied upon, they may give some indication as to the magnitude of the bearing pressures that it is possible for Lignum Vitae and composition bearings to support. You can see from the bearing presssure on the 110" Mill, the amount of pressure that might be required in order to force water into the center of the bearing while it is operating.

C. M. Thompson: Yes, it would be terrific.

The External Heat Loss of a Blast-Furnace*

By D. F. MARSHALL, B. Sc. Tech,
Sheffield, England.

The values obtained and recorded in this paper may be compared with estimates made by others, as in Table I, the calculations being made on a common basis of B.th.u. per lb. of iron produced. In the present series of tests the iron produced was approximately 10,000 lb. per hr.

The most notable difference between the present direct tests and the estimates of the authorities named is that the total loss of heat is smaller than has been considered probable. So far as can be ascertained, however, no previous attempt has been made to determine experimentally the loss of heat by conduction to the ground, and only Bell made any attempt to determine the heat loss by radiation by direct tests. Usually, the heat loss by radiation and conduction has been arrived at as the difference between the heat input and the heat accounted for, and therefore has to carry all the errors of the complicated thermal calculations. Since the results recorded in Table I are frequently quoted, it is desirable to show how they were derived.

TABLE I—Comparison of Different Estimates of the External Heat Loss of a Blast-Furnace (B.th.u. per lb. of Iron).

	Bell.	Richards.	Johnson.	Clemens.	Eichenberg and Oberhoffer.	Author.
Loss in cooling water	162	279	170	943	572	400
Loss by conduction to the ground	304	921	170	782		16
Loss by radiation and convection	324		440		592	64
Total	790	1,200	780	1,725	1,164	480

Bell's results relate to a Cleveland furnace producing 350 tons of pig per week from a total burden (excluding coke) containing 31 per cent. of iron, the coke consumption being 21 cwt. per ton of pig. The furnace had five tuyeres, but was without bosh sprays, and therefore gave a lower loss in the cooling water than a modern furnace. Bell's experimental results were first reported in the Journal of the Iron and Steel Institute for 1869. The cooling water from five tuyeres was measured and amounted to 20,250 litres (4,455 gal.) per hr., the temperature-rise being 16.5° F. The furnace was making 2 tons of iron per hr. The heat loss by radiation was determined with a copper vessel of 19 litres capacity, with an air space of 2 in. surrounded by several layers of flannel on all sides but one. The uninsulated side was placed near the wall under investigation, a distance of ½ in. being maintained by the use of a suitable distance seal. The tank was filled with water and the amount of heat absorbed in a given time was determined. Bell realized that his method of testing prevented any determination of convection losses. It should also be remembered that much of the loss by radiation includes heat from the bosh, which in the present series of tests is included in the cooling-water loss. Finally, Bell subtracted his "transmission chiefly occurring in the lower part of the furnace" from the difference between his heat input and that accounted for in the furnace and the tuyere water, labelling it "escape through the foundations, &c."

Richards' results refer to an American furnace producing 2,500 tons of pig iron per week from a total burden (less coke) containing 43.6 per cent. of iron with a coke consumption of 19.2 cwt. per ton of pig. The cooling water was said to be 300,000 gal. per day, and was heated through 50° C. (90° F.). The round numbers suggest that these records may be approximations. The heat loss by radiation, convection and conduction to the ground was obtained by difference in a thermal balance and therefore carried all the errors of calculation. Richards also gives an estimate of:

	B.th.u. per lb. of iron.
Heat loss in cooling water (determined)	279
Heat loss by radiation. Average	234
Heat loss by conduction to the ground. Average	279
Total	792

This average is the one noted by Evans and Bailey, but there is no basis given by Richards for the apportioning of the heat losses in this way.

Johnson based his calculations on the heat balances of Cornell and Mathesius. Cornell recorded a heat balance for six American blast-furnaces at one plant, each furnace making 3,000 tons of pig per week from a total burden (less coke) containing 38.8 per cent. of iron and with a coke consumption of 20.5 cwt. per ton of pig. The cooling water for the six furnaces was 2,571,240 gal. per day, the temperature-rise being 8° F., giving a loss in the cooling water of 171 B.th.u. per lb. of iron. The heat loss by radiation and convection was obtained by difference from a thermal balance, and amounted to 752 B.th.u. per

*Abstract of Paper to be presented before the British Iron and Steel Institute, May, 1933.

lb. of iron. Mathesius, in a discussion on a paper by Howland, applied his own method of analysis of data to Howland's furnace No. 19. This furnace produced 3,500 tons of iron per week from a burden yielding 42.7 per cent. of iron with a coke consumption of 15 cwt. In an analysis of the data he states: "From the total heat balance obtained in the usual way from the foregoing data, it follows that the actual loss of heat by radiation and cooling water is 918 B.th.u. per lb. of iron. In the calculations which follow, this total loss of heat has been assumed to be 900 B.th.u." He also remarks: "The following assumptions have been made for these heat balances: (a) that two-thirds of the loss of heat through cooling water and radiation takes place in the hearth and one-third in the shaft." Thus it is clear that Mathesius' figures for the external heat loss were obtained by difference from a thermal balance and do not include even a determination of the heat loss in the cooling water.

Johnson accepted Cornell's figure for the heat loss in the cooling water (171 B.th.u. per lb. of iron) and assumed that the heat loss to the ground ("radiation and conduction through the bottom") "would equal this amount which is probably a liberal assumption." He then subtracted the assumed heat loss to the ground (171 B.th.u.) from Cornell's total heat unaccounted for (752 B.th.u.), giving 581 B.th.u. as the heat loss from the shaft. Johnson further accepted Mathesius' assumption that one-third of his heat unaccounted for (including loss in cooling water) was lost by radiation from the shaft, namely, 300 B.th.u., and labelled the mean of these two figures $\{(581 + 300)/2\}$ as "radiation deduced from Cornell and Mathesius, 440 " (B.th.u. per lb. of iron). This basis of his calculation is obviously unsatisfactory. The total external heat losses, or, more correctly, the differences in thermal balances (but including Cornell's determined loss of heat in the cooling water), are therefore: Mathesius 918, Cornell 923 B.th.u. per lb. of iron. Johnson, in effect, assumes that half the difference in the thermal balance is external heat loss from the shaft.

Clements prepared a heat balance for No. 3 furnace, Parkgate, making 1,100 tons of pig per week from a burden (less coke) containing about 30 per cent. of iron. The metered cooling water per 20 lb. of iron was 1,100 lb. with a temperature-rise of 17° F., giving a heat loss in the cooling water of 943 B.th.u. per lb. of iron. He labelled his heat unaccounted for in his thermal balance "radiation, &c.," which amounted to 783 B.th.u. per lb. of iron.

Eichenberg and Oberhoffer prepared a heat balance for a German furnace making 1,600 tons of pig iron per week from a burden (less coke) yielding 45 per cent. of iron with a coke consumption of 18.8 cwt. per ton of pig. They divided their "loss by difference" between two zones, above and below the top of the bosh, on the assumption that the solid materials passed this plane at a temperature of 1,100° C. and the gases at 1,150° C. Reference to one of their Figures shows that the temperature at this plane actually varied between 1,000° C. and 1,300° C. The total loss by radiation, conduction, &c., would be divided in the following amounts, according to whether the gases leaving the top of the bosh were assumed to be at 1,050°, 1,150° or 1,250° C. :

Assumed temperature of gases entering stack. ° C.	1,050	1,150	1,250
External heat loss in stack. B.th.u.	376	592	809
External heat loss in bosh and hearth. B.th.u.	788	572	355
Total. B.th.u. per lb. or iron	1,164	1,164	1,164

The proportioning of the total external heat loss by difference to different zones cannot be made with any accuracy, and large errors are to be expected in such calculations.

It is therefore clear that previous authorities have considerably over-estimated the loss of heat by conduction to the ground. Similarly, the losses of heat by radiation and convection from the shaft have probably been over-estimated, for, assuming an exposed furnace to be subjected to winds of an average velocity of 20 miles per hr. throughout the year, an impossibly high figure, the loss of heat by convection would only be increased in the present instance to 1,148,000 B.th.u. (solution (2)) or to 670,400 B.th.u. per hr. (solution (4)).

On the other hand, relatively large losses of heat by water-cooling are to be expected, since the bosh is the region of highest temperature, the walls are thinnest and the streams of water carry away the heat more effectively than do radiation, convection or conduction to the ground.

The loss of heat in the cooling water for the furnace examined in the present investigation appears to be relatively large in relation to other sources of loss, but it is approximately the means of all the others tabulated in Table I and cannot therefore be considered excessive. A value recently determined on a modern English furnace making 2,500 tons of pig per week is 466 B.th.u. per lb. of iron, which is comparable with that obtained in the present investigation.

It is therefore concluded that, in the past, the external heat loss of a blast-furnace may have been over-estimated, and that in a modern furnace with bosh sprays this loss of heat is mainly in the cooling water. If this conclusion is correct, it follows that other sources of heat consumption in a blast-furnace may explain the relatively large differences between the heat input and that accounted for in the thermal balances which have been constructed.

THE PROTECTIVE TARIFF WAS NEVER NEEDED MORE THAN IT IS NOW

A. C. Cummins Made General Superintendent, Duquesne Works of the Carnegie Steel Co.

A. C. CUMMINS

Alden C. Cummins, who has been assistant general superintendent of the Duquesne Works, Carnegie Steel Company since June, 1932, has been appointed general superintendent of that plant, succeeding the late A. L. Cromlish.

Mr. Cummins, who has been with the Carnegie Steel Company since 1911, has advanced steadily from Assistant superintendent of the Electrical Department, Superintendent of the Ferro-Alloy Furnace and Electrode Factory, Superintendent of the Electrical Department, Director of Power Distribution between Carnegie plants in the Monongahela Valley, Assistant General Superintendent to General Superintendent.

Mr. Cummins has been an active member of the Association of Iron and Steel Electrical Engineers for fifteen years. He has served on practically all of the national committees of the Association. He was Chairman of the Pittsburgh District, later becoming a Director and in 1925 was elected President of this Organization. He was Chairman of the Standardization Committee in 1926, 1927 and 1928 and during that time specifications were prepared and adopted for the standardized commutating pole mill type motor.

Mr. Cummins has contributed to the transactions of the Association of Iron and Steel Electrical Engineers many valuable papers and discussions, among the outstanding ones being:

Developments in Electrical Maintenance Shop Practice.

The Standardized Commutating Pole Mill Type Motors.

Experiences in the Steel Industry with the Grounded Neutral.

Standardization Committee's Final Outline Dimensions for Association of Iron and Steel Electrical Engineers Standardized Mill Type Motor.

The Engineering Industry.

The President and Board of Directors and the Membership of the Association of Iron and Steel Electrical Engineers wish to extend at this time to Mr. Cummins their sincerest congratulations on his advancement to General Superintendent of the Duquesne Works of the Carnegie Steel Company at Duquesne, Pa.

ASSOCIATION NOTES

COMING MEETINGS AND PAPERS

CHICAGO DISTRICT SECTION

MAY 17, 1933 — ELECTRIC ASSOCIATION ROOMS

WELDING SYMPOSIUM*

"THYRATRON CONTROL FOR WELDING" by F. S. Peasely, General Electric Company.

"SHIELD ARC WELDING" by H. M. Downing, Lincoln Electric Company.

"NEW DEVELOPMENTS IN A. C. AND D. C. WELDING" by W. C. Pearson, Westinghouse Electric & Mfg. Company.

"WELDING RODS" by E. A. Hurme, Una Welding, Inc.

*This meeting had been originally scheduled for February 17, but due to inclement weather had been postponed.

ITEMS OF INTEREST

PERSONNEL CHANGES

▲

Howard E. Jeffries, since August, 1931, treasurer of the Carnegie Steel Co., Pittsburgh, has been elected to the board of directors of the company, filling the vacancy caused by the retirement of O. J. H. Hartsuff, general superintendent of Edgar Thomson works, who retired May 1 after 50 years of service.

▲

Frank F. Slick, assistant general superintendent of the Edgar Thomson steelworks and blast furnaces, Braddock, Pa., of the Carnegie Steel Co., Pittsburgh, has been appointed acting general superintendent of the works, succeeding O. J. H. Hartsuff, who retired May 1. Mr. Slick has been assistant general superintendent at that division since August, 1925.

▲

Edward D. Buchanan has been made superintendent of the open-hearth department, Butler, Pa., plant, of the American Rolling Mill Co., Middletown, Ohio. Mr. Buchanan joined the Butler organization before it became a part of the American Rolling Mill Co. as general foreman in the open-hearth department. Shortly after the Rolling Mill company acquired the Columbia Steel Co., he was appointed assistant open-hearth superintendent.

▲

Dr. S. M. Kintner, vice president in charge of engineering of the Westinghouse Electric and Manufacturing Company, announces the appointment of R. E. Hellmund as Chief Engineer. Mr. Hellmund is the first Westinghouse executive to hold this office since the death of B. G. Lamme in 1924.

▲

H. W. Cope, formerly assistant director of engineering, now becomes assistant to the Vice President, responsible for the co-ordination of certain headquarters engineering departments and district office engineers, according to an announcement by Dr. S. M. Kintner, vice president of engineering, of the Westinghouse Electric & Mfg. Company.

▲

Charles Francis Adams, Secretary of the Navy in President Hoover's cabinet, was elected a director of the General Electric Company at the annual meeting of the stockholders, in Schenectady, on April 18. The other directors were re-elected. Owen D. Young, chairman of the board, presided.

▲

The Reliance Electric & Engineering Co., Cleveland, announces that Mr. Harry J. Fisher, who has recently engaged in independent sales work, has been retained as consultant in connection with motor-drive applications in the steel industry.

Previous to October, 1931, Mr. Fisher was connected with the Reliance organization for 14 years, specializing in steel-mill engineering development and sales work.

▲

O. J. H. Hartsuff, general superintendent of Edgar Thomson works, Carnegie Steel Co., Braddock, Pa., resigned and retired from business April 30, after almost 50 years of activity in the steel industry. Mr. Hartsuff was born in New Castle, Pa., studied mechanical engineering and started his business life in 1883 as a machinist with the New Castle Wire Nail Co. Later he was associated with the New Castle Wire Rod Co., Shenango Valley Steel Co., and the National Steel Co. Upon the consolidation of the National with the Carnegie Steel Co., he was made superintendent of the rolling department at New Castle works and furnaces, then superintendent of the Farrell and also the Sharon works, and subsequently general superintendent of these works until April 1, 1920, when he was made general superintendent at Edgar Thomson.

▲

Concluding more than thirty-five years of service with the organization, Albert G. Davis, vice president of the General Electric Company in charge of patents, will retire on May 1, according to announcement by Gerard Swope, president of the company. In making this announcement Mr. Swope alludes to Mr. Davis' "loyal, intelligent and devoted service to the company."

Upon his retirement Mr. Davis will enter the law firm of Pennie, Davis, Marvin & Edmonds, at 165 Broadway, New York. This firm, which specializes in patent work, already includes his younger brother, William H. Davis.

▲

The Esterline-Angus Company has recently placed the Pittsburgh territory in the direct charge of Mr. R. E. Murphy, who for ten years was sales manager of this company.

The Pittsburgh office address has been changed to R. E. Murphy Company, 2902 Grant Building, Pittsburgh.

▲

H. V. Erben has been appointed manager of the Switchgear sales division of the Central Station Department of the General Electric Company, with headquarters at the West Philadelphia Works, it has been announced by J. G. Barry, vice president in charge of sales.

OBITUARIES

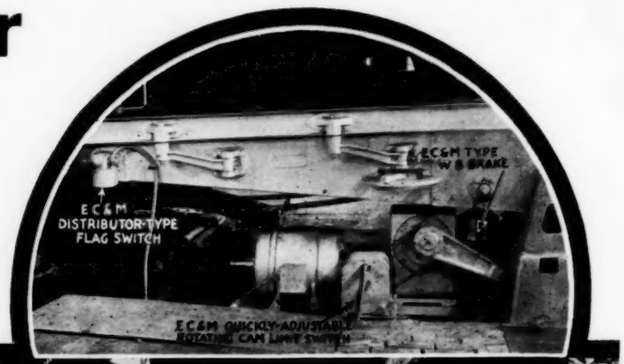
John S. Jenks, vice president and chief engineer of the West Penn Power Company, Pittsburgh, Pa., died March 16, at Mount Pocono, Pa. He was born at Pittsburgh, Pa., in 1873, and before joining the organization of the West Penn Power Company in 1902 was in the organization of the Westinghouse Electric and Manufacturing Company at East Pittsburgh. For the West Penn Power Company he held various positions. As transmission engineer he engaged in work involving right-of-way and the engineering, construction, and operation of transmission lines, substations, and power stations. Subsequently he became assistant to the general manager, later assuming supervision of all activities relating to power service, and then undertook new executive duties as vice president of the company. In 1930 he was elected vice president and chief engineer of the West Penn Power Company, in charge of the electric properties.

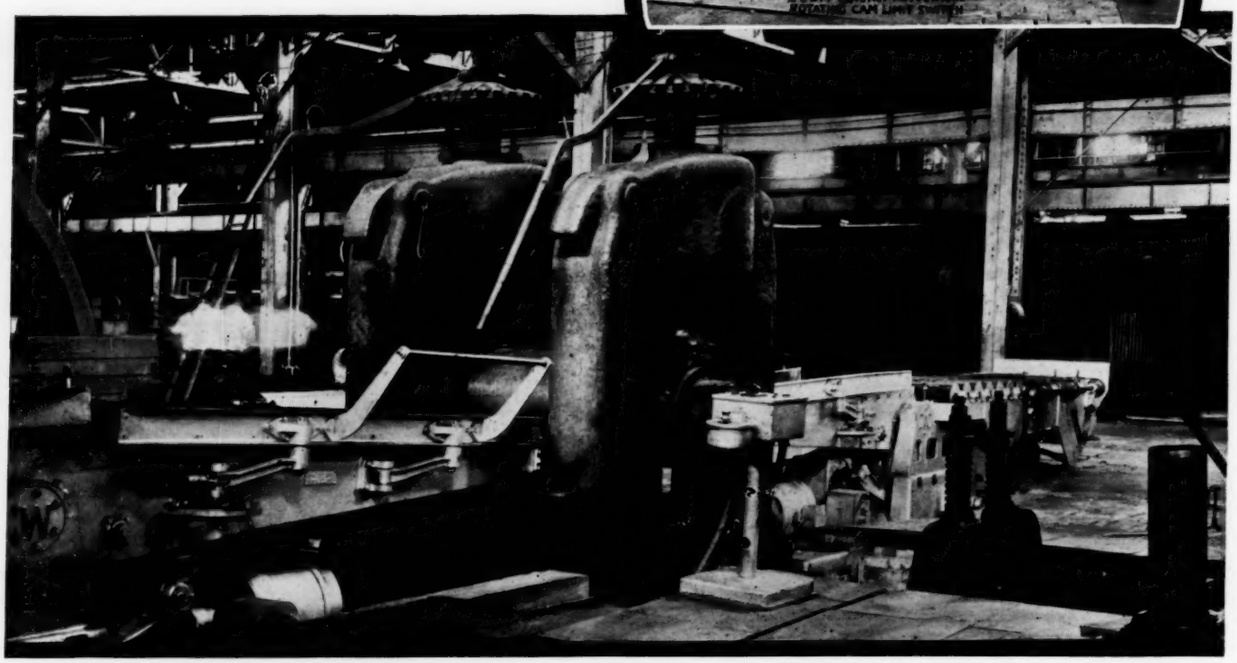
▲

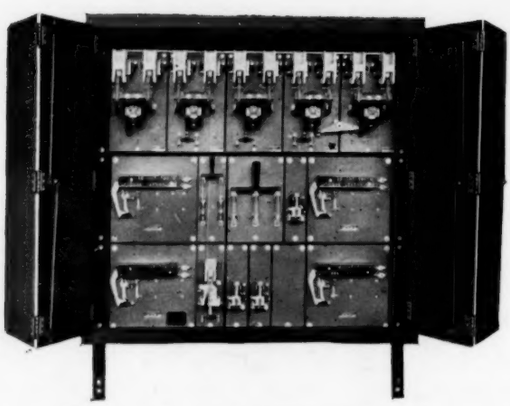
Harold Whitmore Smith, until June, 1932, generating apparatus manager of the Westinghouse Electric and Manufacturing Company and widely known throughout the electrical industry, died in Pittsburgh March 28, after a brief illness.

Feeder-Catcher Tables,

EC&M Controlled







Control and Accessories designed and built to operate 10,000,000 times a year for many years

The most successful installation to date, because--

The EC&M System of Control is thoroughly and soundly engineered. Study of the requirements brought out the fact that the tables should be definitely tied together electrically so that they can not get out of step with each other . . . also, that, at all times and under all conditions, there should be no "dead centers" where the tables can not be operated electrically.

As a result of these outstanding improvements, this installation was started up for the first time without delay and has been functioning successfully ever since. At every point in the cycle of operation, the tables come to rest with definite precision . . . sheets are relayed back and forth in the shortest time possible. This has proven to be the most satisfactory and successful Feeder-Catcher-Table-Control installation to date.

THE ELECTRIC CONTROLLER & MFG. CO.

CLEVELAND, OHIO

NEW YORK - 50 CHURCH ST.
CHICAGO - 310 So. MICHIGAN AVE.
DETROIT - DIME BANK BLDG.
BIRMINGHAM - BROWN-MARX BLDG.
CINCINNATI - 1ST NATIONAL BANK BLDG.
ST. LOUIS - 1027 CLAYTONIA TERRACE
HOUSTON - P.O. BOX 4182
TORONTO - #2 NEVILLE PARK BLVD.
PHILADELPHIA - WITHERSPOON BLDG.
PITTSBURGH - OLIVER BLDG.
SAN FRANCISCO - 420 MARKET ST.
LOS ANGELES - 912 E. THIRD ST.
BUFFALO - 888 COLVIN BLVD.
SEATTLE - 2207 - 1ST AVE. So.